PROCEEDINGS

OF THE

Iowa Academy of Sciences

FOR 1902.

VOLUME X.

EDITED BY THE SECRETARY.

PUBLISHED BY THE STATE.

DES MOINES:
B. MURPHY, STATE PRINTER,
1903.

LETTER OF TRANSMITTAL.

DES MOINES, Iowa, February 20, 1903.

To His Excellency, Albert B. Cummins, Governor of Iowa:

SIR—In accordance with the provisions of title 2, chapter 5, section 136, code 1897, I have the honor to transmit herewith the proceedings of the seventeenth annual session of the Iowa Academy of Sciences.

Respectfully submitted, your obedient servant,

A. G. LEONARD,

Secretary Iowa Academy of Sciences.

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OFFICERS OF THE ACADEMY.

1902.

President—H. E. SUMMERS.
First Vice-President—J. L. TILTON.
Second Vice-President—S. W. BEYER.
Secretary—A. G. LEONARD.
Treasurer—B. SHIMEK.

EXECUTIVE COMMITTEE.

Ex-Officio—H. E. SUMMERS, J. L. TILTON, S. W. BEYER, B. SHIMEK, A. G. LEONARD.
Elective—L. H. PAMMEL, C. O. BATES, M. F. AREY.

1903.

President—B. FINK.
First Vice-President—S. W. BEYER.
Second Vice-President—MAURICE RICKER.
Secretary—A. G. LEONARD.
Treasurer—H. W. NORRIS.

EXECUTIVE COMMITTEE.

Ex-Officio—B. FINK, S. W. BEYER, MAURICE RICKER, A. G. LEONARD, H. W. NORRIS.
Elective—L. H. PAMMEL, C. O. BATES, G. E. FINCH.

PAST PRESIDENTS.

OSBORN, HERBERT	1887–88
TODD, J. E	1888–89
WITTER, F. M	1889–90
NUTTING, C. C	1890–92
PAMMEL, L. H	1893
ANDREWS, L. W	1894
NORRIS, H. W	1895
HALL, T. P	1896
FRANKLIN, W. S	1897
MACBRIDE, T. H	1897–98
HENDRIXSON, W. S	1899
NORTON, W. H	1900
VEBLEN, A. A	1901
SUMMERS, H. E	1902

Constitution of the Iowa Academy of Sciences.

SEC. 1. This organization shall be known as the Iowa Academy of Sciences.

SEC. 2. The object of the Academy shall be the encouragement of scientific work in the state of Iowa.

SEC. 3. The membership of the Academy shall consist of (1), fellows who shall be elected from residents of the state of Iowa actively engaged in scientific work, of (2), associate members of the state of Iowa interested in the progress of science, but not direct contributors to original research, and (3), corresponding fellows, to be elected by vote from original workers in science in other states; also, any fellow removing to another state from this may be classed as a corresponding fellow. Nomination by the council and assent of three-fourths of the fellows present at any annual meeting shall be necessary to election.

SEC. 4. An entrance fee of $3 shall be required of each fellow, and an annual fee of $1, due at each annual meeting after his election. Fellows in arrears for two years, and failing to respond to notification from the treasurer, shall be dropped from the academy roll.

SEC. 5. (*a*) The officers of the academy shall be a president, two vice-presidents, secretary and a treasurer, to be elected at the annual meeting. Their duties shall be such as ordinarily devolve upon these officers. (*b*) The charter members of the academy shall constitute the council, together with such other fellows as may be elected at an annual meeting of the council by it as members thereof, *provided*, that at any such election two or more negative votes shall constitute a rejection of the candidate. (*c*) The council shall have power to nominate fellows, to elect members of the council, fix time and place of meetings, to select papers for publication in the proceedings, and have control of all meetings not provided for in general session. It may, by vote, delegate any or all of these powers, except the election of members of the council, to an executive committee, consisting of the officers and of three other fellows to be elected by the council.

SEC. 6. The academy shall hold an annual meeting in Des Moines during the week that the State Teachers' Association is in session. Other meetings may be called by the council at times and places deemed advisable.

SEC. 7. All papers presented shall be the result of original investigation, but the council may arrange for public lectures or addresses on scientific subjects.

SEC. 8. The secretary shall each year publish the proceedings of the academy in pamphlet (octavo) form, giving author's abstract of papers, and if published elsewhere, a reference to the place and date of publication; also the full text of such papers as may be designated by the council. If

published elsewhere the author shall, if practicable, publish in octavo form and deposit separate with the secretary, to be permanently preserved for the academy.

SEC. 9. This constitution may be amended at any annual meeting by assent of a majority of the fellows voting, and a majority of the council; *provided*, notice of proposed amendment has been sent to all fellows at least one month previous to the meeting, and provided that absent fellows may deposit their votes, sealed, with the secretary.

ARTICLES OF INCORPORATION OF THE IOWA ACADEMY OF SCIENCES.

ARTICLE I.

We, the undersigned, hereby associate ourselves with the intention to constitute a corporation to be known as the Iowa Academy of Sciences, the purpose of which is to hold periodical meetings for the presentation and discussion of scientific papers, to publish proceedings, to collect such literature, specimens, records and other property as may serve to advance the interests of the organization, and to transact all such business as may be necessary in the accomplishment of these objects.

ARTICLE II.

The membership of the corporation shall consist of the incorporators, and such other residents of the state of Iowa as may be duly elected fellows of the academy.

ARTICLE III.

The duly elected officers of the academy shall be the officers of the corporation.

ARTICLE IV.

The principal place of business of the academy shall be the city of Des Moines, in the state of Iowa.

The capital stock of the corporation is none.

The par value of its shares is none.

The number of its shares is none.

ARTICLE V.

The academy shall hold an annual meeting in the last week of December, of each year, or upon call of the executive committee, and such other meetings as may be arranged for.

ARTICLE VI.

This corporation shall have the right to acquire property, real and personal, by purchase, gift or exchange, and such property shall be held subject to the action of the majority of its fellows, or the council, the executive committee, or such parties as it may by vote direct to transact such business in accordance with the constitution.

All deeds, leases, contracts, conveyances and agreements, and all releases of mortgages, satisfactions of judgments, and other obligations, shall be signed by the president or vice-president and the secretary, and the signature of these officers shall be conclusive evidence that the execution of the instrument was by authority of the corporation.

ARTICLE VII.

The private property of the members of this corporation shall not be liable for any of its debts or obligations.

ARTICLE VIII.

By-laws, rules and regulations, not inconsistent with these articles, may be enacted by the academy.

ARTICLE IX.

These articles may be amended at any meeting of the academy called for the purpose by assenting vote of two-thirds of the members present.

MEMBERSHIP OF THE ACADEMY.

FELLOWS.

ALDEN, W. C .... Mount Vernon
ALMY, F. F .... Iowa College, Grinnell
AREY, M. F .... State Normal School, Cedar Falls
BATES, C. O .... Coe College, Cedar Rapids
BEGEMAN, LOUIS .... State Normal School, Cedar Falls
BENNETT, A. A .... State College, Ames
BEYER, S. W .... State College, Ames
CALVIN, S .... State University, Iowa City
CLARK, DR. J. FRED .... Fairfield
COOK, ALFRED N .... Morningside College, Sioux City
CRATTY, R. I .... Armstrong
CURTISS, C. F .... State College, Ames
DAVIS, FLOYD .... Des Moines
DENNISON, O. T .... Mason City
ENDE, C. L .... State University, Iowa City
FINCH, G. E .... Marion
FINK, B .... Upper Iowa University, Fayette
FITZPATRICK, T. J .... Iowa City
FRYE, T. C .... Morningside College, Sioux City
FULTZ, F. M .... Burlington
GOODWIN, J. G .... Indianola
GOW, J. E .... Iowa City
HADDEN, DAVID E .... Alta
HENDRIXSON, W. S .... Iowa College, Grinnell
HILL, G. H .... Independence
HOLWAY, E. W. D .... Decorah
HOUSER, G. L .... State University, Iowa City
KELLY, H. M .... Cornell College, Mt. Vernon
KEYES, C R .... Socorro, New Mexico
KING, CHARLOTTE M .... State College, Ames
KNIGHT, NICHOLAS .... Cornell College, Mount Vernon
KUNTZE, DR. OTTO .... Iowa City
LEONARD, A. G .... Geological Survey, Des Moines
MARSTON, A .... State College, Ames
MACBRIDE, T. H .... State University, Iowa City
MUELLER, HERMAN .... Winterset
NEWTON, G. W .... State Normal School, Cedar Falls
NORRIS, H. W .... Iowa College, Grinnell
NORTON, W. H .... Cornell College, Mt. Vernon

Nutting, C. C. .... State University, Iowa City
O'Donoghue, J. H. .... Storm Lake
Paddock, A. Estella .... State College, Ames
Page, A. C. .... State Normal, Cedar Falls
Pammel, L. H. .... State College, Ames
Price, H. C. .... State College, Ames
Repp, John J. .... State College, Ames
Ricker, Maurice .... Burlington
Ross, L. S. .... Drake University, Des Moines
Sabin, Miss Mary .... State College, Ames
Sage, Hon. John R. .... Des Moines
Sanders, W. E. .... Alta
Savage, T. E. .... Western College, Toledo
Shimek, B. .... State University, Iowa City
Stanton, E. W. .... State College, Ames
Stookey, Stephen W. .... Coe College, Cedar Rapids
Summers, H. E. .... State College, Ames
Tilton, J. L. .... Simpson College, Indianola
Veblen, A. A. .... State University, Iowa City
Walker, L. R. .... State College, Ames
Weems, J. B. .... State College, Ames
Wickham, H. F. .... State University, Iowa City
Witter, F. M. .... Muscatine
Wylie, R. B. .... Morningside College, Sioux City

ASSOCIATE MEMBERS.

Allen, A. M. .... Drake University, Des Moines
Bailey, Dr. Bert H. .... Cedar Falls
Baldwin, F. H. .... Tabor
Biering, Dr. Walter .... Iowa City
Boehm, Walter M. .... State University, Iowa City
Bond, D. K. .... Rockwell City
Boody, Dr. George .... Independence
Bouska, F. W. .... Des Moines
Buchanan, R. E. .... State College, Ames
Carter, Charles .... Corydon
Cavanagh, Miss Lucy M. .... Iowa City
Clearman, Miss Harriet .... Iowa City
Crawford, Dr. G. E. .... Cedar Rapids
Deyoe, A. M. .... Britt
Graven, William N. .... Indianola
Ellis, Sarah .... State College, Ames
Erwin, A. T. .... State College, Ames
Gray, C. E. .... State College, Ames
Green, Wesley .... Secretary Horticultural Society, Des Moines
Guthrie, Joseph E. .... State College, Ames
Hamilton, Dr. Arthur S. .... Independence
Hersey, S. F. .... State Normal, Cedar Falls
Hinkle, Hon. G. W. .... Harvard
Johnson, F. W. .... 521-531 Wabash Avenue, Chicago

LEWIS, W. H ..... Winterset
LIVINGSTON, DR. H ..... Hopkinton
MILLER, A. A ..... Davenport
MYERS, E. C ..... State College, Ames
OSBORN, B. F ..... Rippey
RADEBAUGH, J. W ..... Simpson College, Indianola
SAMPLE, A. F ..... Lebanon
SEAVER, FRED ..... Iowa City
SIMPSON, HOWARD ..... Columbus Junction
SMITH, DR. G. L ..... Shenandoah
STEWART, HELEN W ..... Des Moines
TREGANZA, J. A ..... Britt
WALTERS, G. W ..... Cedar Falls
WILLIAMS, I. A ..... State College, Ames
YOUNG, LEWIS E ..... State College, Ames

CORRESPONDING MEMBERS.

ARTHUR, J. C ..... Purdue University, Lafayette, Indiana
BAIN, H. F ..... U. S. Geological Survey, Washington, D. C.
BALL, C. R ..... Department of Agriculture, Washington, D. C.
BALL, E. D ..... State Agricultural College, Logan, Utah
BARBOUR, E. H ..... State University, Lincoln Nebraska
BARTSCH, PAUL ..... Smithsonian Institution, Washington, D. C.
BEACH, S. A ..... Geneva, New York
BEACH, ALICE M ..... University of Illinois, Urbana, Illinois
BESSEY, C. E ..... State University, Lincoln, Nebraska
BROWN, J. C ..... University of Wisconsin, Madison, Wisconsin
BRUNER, H. L ..... Irvington, Indiana
CALL, R. E ..... 185 Brooklyn Avenue, Brooklyn, New York
CARVER, G. W ..... Tuskegee, Alabama
COBURN, GERTRUDE ..... Kansas City, Kansas
COLTON, G. H ..... Virginia City, Montana
CONRAD, A. H ..... 1621 Briar P'ace, Chicago
CRAIG, JOHN ..... Cornell University, Ithica, New York
DREW, GILMAN C ..... State College, Orono, Maine
ECKLES, C. W ..... University of Missouri, Columbia, Missouri
FAUROT, F. W ..... Missouri Botanical Gardens, Saint Louis, Missouri
FRANKLIN, W. S ..... Lehigh Univ., South Bethlehem, Pennsylvania
GILLETTE, C. P ..... Agricultural College, Ft. Collins, Colorado
GOSSARD, H. A ..... Lake City, Florida
HALL, T. P ..... Kansas City University, Kansas City, Missouri
HALSTED, B. D ..... New Brunswick, New Jersey
HANSEN, N. E ..... Brookings, South Dakota
HANSEN, MRS. N. E ..... Brookings, South Dakota
HAWORTH, ERASMUS ..... State University, Lawrence, Kansas
HEILEMAN, W. H ..... Pullman, Washington
HITCHCOCK, A. S ..... Department of Agriculture, Washington, D. C.
HUME, H. H ..... Lake City, Florida
LEVERETT, FRANK ..... Ann Arbor, Michigan
MALLY, F. W ..... Hulen, Texas

McGee, W. J...... .... Bureau of Ethnology, Washington, D. C.
Meek, S. E.................... Field Columbian Museum, Chicago, Illinois
Miller, B. L.............Johns Hopkins University, Baltimore, Maryland
Mills, S. J...Denver, Colorado
Newell, Wilmon..Agricultural & Mechanical Coll., College Station, Texas
Osborn, Herbert........... .... State University, Columbus, Ohio
Owens, Eliza.... ....Bozeman, Montana
Patrick, G. E.............Department of Agriculture, Washington, D. C.
Read, C. D...................... Weather Bureau, Vicksburg, Mississippi
Sirrine, F. A...................124 Sound Avenue, Riverhead, New York
Sirrine, Emma..Dysart, Iowa
Spencer, A. C...............U. S. Geological Survey, Washington, D. C.
Stull, W. N...............Harvard University, Cambridge, Massachusetts
Todd, J. E............. ......State University, Vermillion, South Dakota
Trelease, Dr. William.............................St. Louis, Missouri
Udden, J. A...Rock Island, Illinois
Wilder, F. A...............................Grand Forks, North Dakota
Winslow, Arthur.................................Kansas City, Missouri
Youtz, L. A .... New York City, New York

PROCEEDINGS

OF THE

SEVENTEENTH ANNUAL SESSION

OF THE

IOWA ACADEMY OF SCIENCES.

The seventeenth annual session of the Iowa Academy of Sciences was held in the rooms of the Iowa Geological Survey at the capitol building, December 30 and 31, 1902. In the business session the following matters of general interest were passed upon.

REPORT OF THE SECRETARY.

To the Members of the Iowa Academy of Sciences:

During the past year fifteen additions were made to the list of fellows. Eleven of these were associate members who having become eligible were transferred to the fellowship list, and four were newly elected members. Three fellows, Messrs. Faurot, Leverett and Miller, having removed from the state, were transferred to the corresponding membership list. The number of associate members was increased by the addition of twelve new names. The revised roster now shows seventy-two fellows, fifty-nine associate members and forty-eight corresponding members, making the total membership of the academy 179. Four fellows, Messrs. Brown, Eckles, Stull and Wilder, have removed from the state and should be transferred to the list of corresponding members. During the year just past the academy has suffered the loss of one of its most honored members, President W. M. Beardshear, and I would recommend that a committee be appointed to prepare a suitable memorial.

The legislature last winter passed two bills relating to the publication of the proceedings. One of these increases the number of pages that may be printed from 250 to 300, thus adding fifty pages to the number the annual

volume may contain. The secretary of state, however, who authorizes the payment of all bills for state printing, has ruled that the 300 pages shall include the illustrations. When these are numerous, as is the case in the last volume of the proceedings, this reduces quite materially the number of pages of reading matter that may be published. The other bill provides for the purchase of the necessary cuts and plates for the illustrations and does away with the trouble previously experienced in getting the bills for these allowed by the executive council.

During the past year there has been the usual annoying delay in getting the volume of the proceedings printed and bound. Owing to the press of legislative and other state printing incident to the meeting of the legislature it was late in the summer before the state printer began work on the proceedings, and afterward they were held for nearly two months in the bindery. But volume IX has finally been received and is being distributed as rapidly as possible. Including the illustrations it contains 300 pages and makes the largest volume yet published.

Respectfully submitted,

A. G. LEONARD,
Secretary.

REPORT OF THE TREASURER FOR 1902.

RECEIPTS.

Balance from 1901	$ 38.01
Back dues	5.00
Annual dues, sixteenth meeting	14.00
Annual dues, seventeenth meeting	15.00
Initiation and transfers	6.00
Sale of reports by secretary	7.00
Total	$ 85.01

DISBURSEMENTS.

Lantern for lecture	$ 5.00
Printing and stationery	14.50
Half-tone cut	3.00
Expenses	3.47
Stamps, telegrams, secretary	10.38
Stamps, express, telegrams, treasurer	2.46
Total	$ 38.81
Balance on hand	46.20

At a meeting of the council of the academy the following fellows and members were elected:

FELLOWS.

T. C. Frye, professor of biology, Morningside College, Sioux City; B. L. Lanphear, assistant professor of electrical engineering, Iowa State College, Ames; D. W. Morehouse, professor of physics and astronomy, Drake University, Des Moines; H. C. Price, professor of horticulture, Iowa State College, Ames.

ASSOCIATE MEMBERS.

A. M. Allen, Drake University, Des Moines; R. E. Buchanan, Iowa State College, Ames; Miss Lucy M. Cavanagh, State University, Iowa City; Miss Harriet Clearman, Iowa City; Fred Seaver, State University, Iowa City.

CORRESPONDING MEMBERS.

J. C. Brown, University of Wisconsin, Madison, Wisconsin; C. H. Eckles, University of Missouri, Columbia, Missouri; W. N. Stull, Harvard University, Cambridge, Massachusetts; F. A. Wilder, Grand Forks, North Dakota.

The following officers were elected for the ensuing year:

President.—B. Fink.
First Vice-President.—S. W. Beyer.
Second Vice-President.—Maurice Ricker.
Secretary.—A. G. Leonard.
Treasurer.—H. W. Norris.
Elective Members of the Executive Committee.—L. H. Pammel, C. O. Bates, G. E. Finch.

It was moved and carried that notice be given of an amendment to the constitution changing the time and place of meeting; that hereafter the time and place of meeting shall be fixed by the executive committee, notice of the meetings to be sent out at least three months beforehand.

The committee on a pure food law submitted the following report:

REPORT OF THE COMMITTEE ON A PURE FOOD LAW.

The work of the committee for the past year has been closely connected with the preparation and presentation of a pure food law to the Iowa legislature. In co-operation with the committee of the state horticultural society a pure food bill was prepared after the proposed national pure food bill and the pure food laws of other states. This bill was presented to the house of representatives by Hon. Eugene Secor, but failed in the committee on appropriations. At the time of the presentation of the bill a copy of the following circular letter was sent to each member of the legislature:

SOME SUGGESTIONS.

(1) The pure food bill asks for an appropriation of $10,000, and the first thought is that this is a large sum. It means over one hundred dollars for each county.

(2) One hundred dollars for each county; and the next thought that comes to us is, "What will be the result from the investment of the one hundred dollars?" Our neighbor, Mr. A., is a cattle feeder. He will probably use 500 or 600 tons of some feeding product, say cotton seed meal. This substance varies from 23 to 50 per cent of protein, but for our purpose say 32 to 40 per cent. The feeder purchases the meal for the protein and fat, but the protein is the most important Five hundred tons of 32 per cent meal contains 160 tons of protein, while 400 tons of 40 per cent protein will contain the same amount. The dealer or manufacturer has different grades of meal. Will he send the 40 per cent meal to Iowa or will he send it to the eastern states, where food inspection is required and the analysis published? The chances are that the Iowa feeder will get the 32 per cent while his eastern brother will get the 40 per cent. The eastern man pays freight on 400 tons while the Iowa man pays freight on 500 tons for the same amount of protein. The freight on 100 tons of the meal alone at $3 per ton is $300. It would be a paying investment for the feeder to donate the $100, as he would save $200, in addition to the original cost of the meal.

(3) The average family will use in one year at least two pounds of cream of tartar or its equivalent as baking powder. Cream of tartar sells for 60 cents per pound, but say 30 cents, for our purpose. If a town contains 500 families, it means that they will purchase 1,000 pounds of cream of tartar in the year. Cream of tartar is adulterated with gypsum, starch, etc., in some cases to the extent of 90 per cent, but say 50 per cent; 1,000 pounds of 50 per cent cream of tartar (?) at 30 cents is $150. This sum is paid for the materials of no value whatever as food. It would be a paying investment for the town to donate the $100 as its part of the appropriation.

From the two examples given the question is only "How many thousand per cent will the investment of $10,000 return for the people of the state?" A return of 6 per cent is considered good, but what of 1000 per cent return and the original investment?"

(4) It is said that our people like to be cheated and humbugged, but is this true, or can it be said to be due to ignorance? Is it not true that the state does not furnish its citizens information on the subject of foods? There is no desire to prosecute the dealer, but the purchaser should have some means of knowing what he is purchasing and some protection, in order that the guarantee given by the dealer or manufacturer may be of value.

(5) The results of a food law are largely educational. It tells the family regarding the food it uses, the grocer regarding the foods he is selling, the feeder and stockman regarding the feeding materials he is feeding his animals.

The question is, "Can $100 for each county be better invested for the benefit of the citizens of the state than in a pure food law?"

Respectfully suggested

Chairman Committee on Pure Food Law,
Iowa Academy of Sciences.

It appears very unfortunate that our people are not interested in the pure ood question sufficiently to have their representatives provide a pure food law for their protection.

It is respectfully recommended that the committee on a pure food law be continued in order that this important question may be kept before the people of Iowa.

Respectfully submitted,

J. B. Weems, *Chairman.*
C. O. Bates.
Maurice Ricker.
Nicholas Knight.
W. S. Hendrixson.

On Wednesday evening, December 31st, the members of the academy had the privilege of listening to an illustrated lecture by Professor T. H. Macbride on the subject "The Desert of Sonora." The lecture was given under the joint auspices of the academy and the science teachers' round table of the State Teachers' Association.

At the literary sessions the following papers were presented:

The presidential address, "Some Problems of Heredity and Evolution."—H. E. Summers.

"Some Ecological Notes on the Vegetation of the Uintah Mountains."—L. H. Pammel.

"Living Plants as Geological Factors."—B. Shimek.

"The Solar Surface During the Past Twelve Years."—David E. Hadden.

"The Origin of the Lignites of North Dakota."—Frank A. Wilder.

"Smallpox in the Public Schools."—L. H. Ford.

"Notes from the Chemical Laboratory of Cornell College."

"A Study of Psychopathic Heredity."—W. E. Sanders.

"Some Observations upon the Action of Coherers when Subjected to Direct Electromotive Force."—Frank L. Almy.

"The Accretion of Flood Plains by Means of Sand Bars."—Howard E. Simpson.

"The Duck Hawk (*Falco peregrinus anatum*) in Iowa."—B. H. Bailey.

"The Membrane Bones in the Skull of a Young Amphiuma."—H. W. Norris.

"The Preparation of Phenylether."—A. N. Cook.

"The Sioux City Water Supply."—A. N. Cook and W. J. Morgan.

"Significance of the Occurrence of Minute Quantities of Metallic Minerals in Rocks."—C. R. Keyes.

"Genesis of Certain Cherts."—C. R. Keyes.

The Chemical Composition of Nuts Used as Food."—J. B. Weems and Alice W. Hess.

"The Preparation of Ammonia Free Water for Water Analysis."—J. B. Weems and E. C. Myers.

"The Toledo Lobe of the Iowan Drift."—T. E. Savage.

"The Scrophulariaceæ of Iowa."—T. J. and M. F. L. Fitzpatrick,

NECROLOGY.

WILLIAM MILLER BEARDSHEAR.

BY L. H. PAMMEL.

Dr. Beardshear became a member of the Academy of Sciences soon after he was elected president of the Iowa State College. He took an active interest in its progress, though never presenting any papers. He was, however, deeply interested in building up the scientific side of every department represented by the academy. He saw the importance of science in all of its phases to human industry and education. In his death the academy loses an active friend and supporter.

The writer's acquaintance with Dr. Beardshear began when he delivered one of the Sunday morning addresses at the college chapel in 1890. This address, like others of his it was my privilege to hear, was full of noble thoughts and expressions. Early in 1891 he was elected to the presidency of the Iowa State College, and one of his first official acts was to preside at the experiment station council, at which the members of the station council had gathered for the purpose of outlining a policy of the work to be carried on by its staff. On this occasion, as in all others where he dealt in an official capacity, he was tactful and cautions. His success as an executive rests largely in his tactful way and the kind consideration he gave to all matters coming before him. This won for him the respect and confidence of his colleagues. I had the privilege also of being associated with him on the geological board, where every question was treated in a broad minded manner. As a member of the faculty I found him ever considerate for the wants

WILLIAM MILLER BEARDSHEAR.

and needs of the student body. He outlined policies that were not narrow or one sided. He always worked for the full and complete development of the student. Mental training was not sufficient, but the social side of the student as well as athletics must needs receive attention. He wished the college to turn out men and women in the broadest sense.

Dr. Beardshear had two requisites for a successful college president. One was a commanding presence, which at once caused him to receive respectful consideration. He never had to resort to unusual methods as the student obediently followed his suggestions. Secondly, he had splendid executive ability. He was careful never to commit himself to a student, and by an instinctive process brought out what the student had to say. He then dealt with the student body as his conscience dictated.

Dr. Beardshear was a great lover of the beautiful in nature; the trees and flowers were an inspiration to him. He knew them from boyhood. When as a boy he had to cut trees on an Ohio farm, or afterwards roaming through the woods on a hunt, the trees and flowers became an open book to him. I remember a long talk I had with him when he returned from Montauk, New York, where he had been attending a meeting of the United States Indian Commission. The beautiful chestnut oaks on those grounds appealed to him. He had a strong affection for his old home in Ohio where his aged mother continued to reside until her death, and where he made a yearly visit. His home ties were equally strong and he had the strongest affection for his family.

The chief events of his life are as follows: He was born at Dayton, Ohio, November 7th, 1850, and his boyhood was spent on the farm. He entered the army of the Cumberland at fourteen years of age, his early education having been attained in the public schools of Ohio. He received the degree of Bachelor of Arts from Otterbein University in 1876, and later the degree of Master of Arts from the same school; he also received the degree of LL. D. from his alma mater. He took two years post graduate work at

Yale University. He was a minister of the United Brethren church and held pastorates at Arcanum and Dayton, Ohio. He was president of Western College, Toledo, Iowa, from 1881 to 1889, and at that time was one of the youngest college presidents in the United States. He brought Western College from an obscure institution to one of standing among the colleges of the states. He was superintendent of the city schools of Des Moines from 1889 to 1891, where he displayed unusual executive abilities. To be a successful city superintendent requires tact and ability of an unusual kind, and he had both to a marked degree. He was president of the Iowa State Teacher's Association in 1894; served a term on the executive committee of the Iowa State Teacher's Association; was director of the National Educational Association from Iowa for a number of years, and was president one year of the Department of Manual Industry and Training of that association; he was president of the Iowa State Improved Stock Breeder's Association in 1899, and delivered an annual address that will long be remembered as a powerful one. In his delivery he displayed all of his powers of oratory, combined with wit and wisdom. He was a member of the United States Indian Commission since 1897; was juror on Educational Awards at the Pan-American Exposition, Buffalo, in 1901, and president of the National Educational Association, 1901-1902. He died August 5th, 1902, at Ames, Iowa.

One of his strongest addresses was delivered at the commencement exercises at Ames in June, 1902. The same month he delivered an address at Manhattan, Kansas, at the National Educational Association. Dr. Beardshear was the first president of the National Educational Association to come from the state colleges. He had worked earnestly to extend the scope of this body, as well as the association of agricultural colleges and experiment stations. In this body at the San Francisco meeting he had a resolution introduced, which was carried, looking for greater co-operation between the National Educational Association and the state colleges.

A large concourse of mourning friends attended the funeral services, held in the college chapel at Ames, on August 7th, where addresses were made by President Bookwalter, Professors Stanton and Loos, Superintendent Barrett and Mr. Boyd.

One of the best estimates of President Beardshear may be found in what President Bookwalter said in speaking of him as a man. "His strength lay as always, chiefly in his greatness of heart. His whole career was marked and made illustrious by his lofty, self-sacrificing devotion to the good of others. He literally gave himself without stint—alas, as it would seem, with too little thought of an overtaxed body—to the great interests committed to his care. But we would not have had him less the great hearted servant he was, the follower of Him who 'came not to be ministered but to minister.' What a noble soul he was. How fit and valuable a teacher and leader of the young. His life was emphatically an outpour. And what an outpour, what an overflow, watering the waste places and making everywhere the lilies to grow."

Equally noble sentiments were expressed by Prof. Stanton, in his address at the memorial services for the college students on September 7th. "Two days in college history —February 17, 1891, and August 5, 1902—stand out before me in a similar impressive way. On the one, a great and lofty soul came into touch with a great and lofty mission. On the other, undaunted, triumphant, glorified, with the spirit of a true soldier, our beloved president answered the summons which called him into higher fields of duty. Between these dates lies the greatest work of Dr. Beardshear's life, a work sanctified by such full measure of devotion, courage and self-sacrifice as lights up the grief and mystery of to-day with a far reaching, prophetic hope, and confirms our faith in the God-like possibilities of human living."

PRESIDENTIAL ADDRESS.

SOME PROBLEMS OF HEREDITY AND EVOLUTION.

BY H. E. SUMMERS.

Of all biological problems none is of more importance and interest to the mass of mankind than that dealing with the laws of evolution. To the biologist, of course, these laws are of prime importance, as expressing the ultimate result of all life processes. But I refer here rather to the widespread interest among all classes of educated people, due, I believe, to a feeling that as our human civilization is advancing in conformity with these laws, a fuller knowledge of them might enable us the better to guide and control our progress in the future.

Underlying the laws of evolution, however, we have the laws of heredity. A knowledge of the latter is a necessary prerequisite for a full understanding of the former. Problems of heredity and evolution are so interwoven that it is impossible entirely to separate them. Indeed, probably the most important question to the student of evolution to-day, that as to the transmissibility of acquired characters, is a question of heredity. It is to a review of some of the *problems of heredity*, therefore, that I shall mainly devote this paper.

Let us have clearly before us the meaning of the term heredity.

1. Every individual organism develops from a germ (in the animal the ovum or egg), of relatively small size and *apparently* simple structure, which in the great majority of cases has no vital connection with its parent after the beginning of its development.

2. During its development it passes through a series of successive stages similar to those through which its parent passes at corresponding periods, and finally on reaching maturity resembles that parent closely in form and function; indeed, is identical with it, except in those minor characters called individual.

3. The direction of development must be determined by either one, or both, of two sets of conditions: the first *internal*, namely, the structure and resident forces of the ovum given to it by the parent; the second *external*, the matter and forces reaching it from without. The internal sets of conditions we call *heredity;* the external, the *environment.*

These two factors are constantly co-operating in every developing organism; but, as we shall see, the relative importance assigned to each by different biologists varies enormously.

To explain the operation of the first factor, heredity, many hypotheses have been proposed. These may be divided more or less completely into two groups, preformism and epigenesis.

Theories of preformation suppose that in the germ are represented in some way all the various parts of which the adult is composed. Development then consists merely in the growth and unfolding of these parts. The germ is consequently of a complexity comparable to that of the adult, its *apparent* simplicity of structure being due to our inability to distinguish the parts present on account of their minuteness. Theories of epigenesis suppose that the germ is *really* of a relatively simple structure, and that development consists in the actual addition of new parts in an orderly manner under the control of the parts previously present and the forces of the environment.

For the beginning of preformation theories we must go to the ancient Greeks. Democritus, about 400 B. C., supposed that the germ was built of very minute corpuscles derived from all parts of the body of the parent, these corpuscles having the power to grow enormously, each at its proper time, and so reproduce the part from which it

was originally derived. In other words, the individual was preformed in the germ, and its development was therefore a process of unfolding. This idea was accepted or independently proposed by a number of naturalists, until finally it was put forth by Darwin in a carefully elaborated form, with a wealth of illustration, as the "Provisional Hypothesis of Pangenesis."

The theory assumes that all the cells of an organism produce minute corpuscles, called gemmules, which after their formation are scattered throughout the body. These gemmules are produced not only in the adult organism, but at all stages of development; since their production depends on the physiological maturity of the cells from which they are derived, not on that of the entire organism.

These gemmules have the power of absorbing nourishment and increasing in number by self-division. They have for one another an affinity which causes them to come together in the reproductive glands, the aggregate of all the different kinds collected there in the germ cells constituting the material basis of heredity. Development consists in the growth of a portion of each kind of gemmule into cells like those from which it originated. All the gemmules in the germ cells, however, do not so develop, but many of them, probably the greater part, are passed on unchanged and may develop in a later generation; hence the phenomenon of reversion. Before their aggregation in the germ cells, while still scattered through the system, the gemmules may under certain conditions develop; in this way the reproduction of lost parts may be accounted for.

Many objections to the theory of pangenesis, apart from general objections to all preformation theories, have been brought forward, but there is not here time to consider them in detail. One or two of a somewhat general character may, however, receive brief mention.

It is assumed that the gemmules are given off at all periods of development, and hence a large share of them must be derived from immature organs; and it would seem as if there would be a constant tendency for each succes-

sive generation to resemble, not the adult of the preceding, but early stages of the immature organism. It is an established fact that new characters appear in most cases at or towards the close of individual development, but as offspring are largely produced before this time, it is an absolute impossibility that gemmules should pass into the hereditary substance from the organs of the parent in their modified state.

When we try to discover the time at which the predominant mass of gemmules is given off from the various organs, we find the above objection becoming even more important than it at first seemed. If in an animal at a very early stage of development, certain organs are entirely removed, rendering it impossible for those organs to give off gemmules, nevertheless such organs are produced in the offspring of the next generation as if there had been no mutilation in the parent.

Another general objection is based on the inconceivability of the gemmules reaching their proper locations in the germinal substance built up from them, and unless we assume that they do reach a definite location and thus build up a definite structure, it is inconceivable that the various parts of the adult arising from their development should have the proper relations one to another.

A large share of the objections to the theory, although when taken as a whole, they are the most important of all, cannot be entered into here as they would lead us into a discussion of masses of details of structure and development not suited to a paper of this kind. It may be stated, however, that these are on the whole so forcible that biologists in general have been compelled to abandon the theory of pangenesis as untenable.

Another hypothesis of the origin of the germ, entirely opposed to that of pangenesis and related theories, is that which has come to be known under Weismann's name, the *continuity of the germ plasm.* This biologist, although not the first propounder of the main idea which gives a name to this theory, has so elaborated the original fundamental hypothesis that it is usually connected with his

name. Germ plasm is the name given to the material of the germ in which heredity resides. As the germ developes this material controls the development by dividing up for the most part, and passing out into the different parts of the body to form the protoplasm of the body, or the somatoplasm, in a manner that we may suppose to be the same as that by which a mass of gemmules in the theory of pangenesis accomplishes the same purpose. But, and here is the essential part of the theory, *a portion* of the germ plasm does not take part in this process, but is reserved; that is, it does not come into activity in controlling the development of that particular germ, but is simply passed along unchanged in a certain chain of cells that ultimately lead up to and form the reproductive glands. When certain cells of these glands become germ cells, the germ plasm is therefore already a constituent of them. The theories of pangenesis and of the continuity of the germ plasm do not therefore *necessarily* differ in the relation between the material basis of heredity and the development of the individual, but they are diametrically opposed as to the source of this material basis of heredity in each generation. Pangenesis supposes that the germ plasm is newly formed in each generation; the other theory that it is passed on ready formed from generation to generation—that is, that it is *continuous* from generation to generation.

While the character of the somatoplasm is determined by the germ plasm, since it arises from it during development in each generation, the structure of the germ plasm is not in a reverse manner determined by the somatoplasm, since the germ plasm is not produced by the somatoplasm. but is simply handed along from the preceding generation. It must not be understood that changed conditions to which the individual is subjected cannot at all influence the germ plasm, for of course the latter is dependent on the rest of the body for its nourishment, and anything that interferes with the proper supply of this, in kind or quantity, must affect both somatoplasm and germ plasm. But there can be no *representative* changes produced in the germ

plasm by conditions which affect the development of particular parts of the body; that is, exercise of an arm, although modifying the structure of that arm cannot affect especially the *particular* part of the germ plasm which represents the arm, that is which controls the development of the arm.

Weismann's theory of the continuity of the germ plasm cannot, in its essentials, be classed either with the preformation or epigenesis theories; for this division is based on the *nature* of the basis of heredity, not on its *source.*

But Weismann has built upon this original idea a theory of the structure of this germ plasm that presents an extreme case of preformism, and which has to a great extent driven other theories of this class from the field. He identifies the germ plasm with the chromatin of the nucleus, and sees in the complicated process by which this chromatin is split up during cell division the mechanism by which the proper portions of the germ plasm (or chromatin) are accurately allotted to those parts of the body whose development they control.

All preformation theories are open to the general philosophical objection that they try to explain a complicated bodily structure by an equally and perhaps even more inexplicable complexity in the germ plasm, instead of explaining this complexity by showing how it might have arisen from a relatively simple condition in conformity with known laws. If Weismann's views of the structure of the germ plasm are true, we have presented to us the problem of explaining how its marvelous complexity could have arisen; a problem that is not rendered less great certainly be removing the structures from the region of the visible to that of the invisible.

All preformation hypotheses attribute, as will be at once seen, the major influence during development to heredity. As the individual is already represented in all its parts in the germ, the environment plays a very subordinate part, its influence being confined mainly to the providing of nourishment for growth. Of course, all external influence is not excluded, but it must be looked

upon as resulting in the production of slight variations from the type, rather than as actively co-operating with heredity to bring about a typical development.

In strong opposition to this point of view are the epigenetic theories of heredity. These attribute far more importance, throughout the whole period of development, to the external factor, environment. The germ, like all other living matter, is of course regarded as of extremely complex organization, but the various elements composing it in no way represent corresponding elements of the adult body into which it is to develop. We have a mass of protoplasm, capable of growth by the assimilation of new material from the outside; responding during that growth, however, to all the various kinds of stimuli from the environment,—heat, light, electricity, chemism, moisture, oxygen, molar impulses, adhesive force, pressure, etc. Even supposing the protoplasm constant in structure, changes in these various forces would produce different reactions. So long as the environment does not vary too much from the normal, some reaction may be looked for; but if too great a variation occurs development will cease. But the protoplasm of the germs of different species may differ much in structure, and consequently in the exact response that will be made even to the same environmental forces; in other words, the protoplasm exerts a selective power not only on the elements of food to be assimilated, but also on all the other external forces; thus different germs respond differently even in identical environments. The first growth and change of form, however, puts the organism into a new and different relation to the environment, in which the external forces will produce necessarily different results; and so every successive stage in development will have its own peculiar relation to the environment, and make its own peculiar responses, even though that environment remains constant. But while the organism reacts to the environment, so it also reacts upon it so as to modify it to some extent; also while the organism reacts to the environment by undergoing internal modifications of function, it also reacts to it by

changes in position in relation to it, so that as it develops it may travel into quite different conditions from those prevailing at first. Hence we see that even a slightly different response to external forces in the first stages of development, due either to a different protoplasmic structure or to differences in these forces themselves, may produce ultimately important results. To put the case in a strong form I may quote from Ryder: "The initial configuration or mechanical arrangement and successive rearrangements of the molecules of a germ, the addition of new ones by means of growth, plus their chemical and formal transformation as an architecturally self-adjusted aggregate, by means of metabolism, is all that is required in an hypothesis of inheritance."

While the theories of pangenesis and of the continuity of the germ plasm are in themselves of great scientific interest, they would probably not have attracted so much attention from people who are not especially devoted to biological problems were it not for their relation to certain theories of evolution. Characters appearing in an individual during development may be regarded as arising from the operation of either one or two sets of forces, those from heredity (such characters being called *congenital*) and those from the environment (such characters being spoken of as *acquired*).

Darwin assumes that characters acquired in one generation become, at least to a certain extent, congenital in the next. By the hypothesis of pangenesis this is easily accounted for, since the gemmules are given off from the organs that have been modified during the whole life of the individual, and will hence modify the hereditary substance in the germ after the characters have been acquired. The theory of the continuity of the germ plasm, implying as it does the impossibility of representative changes in the germ plasm, due to modifications of the somatoplasm, does not provide for the transmission of acquired characters.

Weismann was led, in consequence of this and other considerations, to deny absolutely the possibility of acquired characters being congenital, or in other words, he denied

the possibility of the transmission of acquired characters. It is in connection with this hypothesis that he has become most widely known, and it is upon the affirmative or negative decision in regard to it that the biologists of the world to-day stand divided into two opposing schools. Neo-Darwinians, following Weismann in not being able to account for the evolution of forms in any degree by the transmission of acquired characters, have been forced into the position of accounting for all such evolution through the distinctively Darwinian factors, natural selection and sexual selection.

Neo-Lamarckians, in accepting the possibility of the transmission of acquired characters, have been compelled to deny the validity of the theory of the continuity of germ plasm, at least when that theory is held, as by Weismann's school, to include the idea of the absolute independence of the germ plasm of all representative influences derived from the somatoplasm. Of course it is not necessary in holding this view to discard the Darwinian factors, and in fact most Neo-Lamarckians accept these as effective, but attribute to them greatly varying degrees of relative importance.

The Neo-Darwinians, whether they be right or wrong, have intrenched themselves in a very strong position, from which it is difficult to dislodge them. Presenting strong presumptive evidence against the inheritance of acquired characters, they ask those who believe in such inheritance to present proof of a single case in which an undoubted acquired character has become congenital. Now, such proof is very difficult to obtain, and indeed some of the most eminent Neo-Lamarckians have acknowledged that it has not yet been forthcoming.

Neo-Lamarckians have, as has been said, generally accepted as untenable the theory of pangenesis. There has been accumulated, however, a mass of evidence to prove that selection (natural or sexual) is insufficient to account for *all* the observed facts of evolution. This evidence is particularly abundant in paleontology. Before selection can act, a variation must possess some *utility;*

that is, it must have a *survival value.* But many paleontological series show the origination and gradual increase in a large number of individuals simultaneously of characters which in their first stages could have possessed no utility, and only after many generations reached a sufficient degree of development to have a survival value. Such *progressive adaptations* are regarded by the Neo-Lamarckians as positively disproving "the all-sufficiency of natural selection."

We are now in position to appreciate a dilemma into which we have fallen, which reminds us forcibly of the inadequacy of our present knowledge of this subject. If, as held by the Neo-Darwinians, acquired characters are not transmissible, then such progressive adaptations as those mentioned above cannot be explained. If, on the other hand, as held by the Neo-Lamarckians, acquired characters are transmissible, then the method of such transmission remains to be explained. In the words of Osborn, "If acquired variations are transmitted, there must be therefore some unknown principle in heredity; if they are not transmitted, there must be some unknown factor in evolution."

For several years biologists have been trying to find some factor or factors of evolution that would bridge over the apparent gap between Neo-Lamarckism and Neo-Darwinism. Three investigators, Morgan, Osborn and Baldwin, have independently brought forward an idea which seems at least in part to accomplish this result. Baldwin, who has most fully elaborated this theory, has applied to it the name of *orthoplasy.* Account is taken of the undoubted fact that changes in the environment product important modifications in individuals, although such acquired characters are not assumed to be transmissible. The acquirement of characters in this way enables the individual to meet changes in the environment which without them might be so unfavorable as to cause their extermination. They thus live to produce offspring, which, although they do not *inherit* the acquired characters, develop them independently under the influence of

the same environment. It should here be particularly noted, however, that in the same environment there would be no *progressive* adaptation under the influence of this factor alone; each generation would be modified to the same degree as the first that found itself in the new environment. Nevertheless, large numbers of individuals would be protected from extermination for successive generations and so full opportunity given for favorable fortuitous congenital variations to arise, which would be perpetuated by selection. To be favorable, such variations would be in the same direction as the acquired characters, although not in any sense caused by them. In the words of Conn, in a review of the theory, "The chief significance of this theory, then, is that it greatly prolongs the time over which the race might wait for the appearance of proper congenital variations."

For some time it has seemed to me that I could perceive another method of evolution, similar in many features to orthoplasy, which would still further harmonize some of the apparently opposing views of Neo-Lamarckians and Neo-Darwinians.

It appears to me that insufficient emphasis has been placed on the *variation* in the ability of different individuals to respond to new stimuli, that is to changes in the environment. When a number of individuals are subjected to new conditions, implying increased stimuli to certain. parts, either by increased use or the direct influence of the environment, it is impossible to predict how much change will occur in the different individuals; but certain it is that they will differ very much in this respect. Some domestic animals respond feebly to better care, others strongly: put a number of boys through a gymnasium course, and while the muscles of all may be much developed at the end, the differences are usually startling; send two children of the same parents to the same school, and have one come out with a keenly developed intellect, the other mediocre.

Now, I believe such variations will be the most numerous, and greatest in degree, when *there is a need of new*

characters developing to meet changed conditions. For when the environment remains constant for a large number of generations, those qualities of the germinal substance which lead to the development of unfavorable characters under the influence of the environment in question will be eliminated by the extinction through selection of the individuals arising from that germinal substance. There will thus arise a gradually increasing fixity of type. But this fixity, while implying an absence of qualities in the germinal substance that would cause variations under the environment in question, does *not* imply the absence of variable qualities in the germ which take no part in development under the given environment, but *might* do so under some other environment; for *such variability has never been eliminated by selection.* Hence when conditions change, such variations are likely to become at once conspicuous.

Perhaps this may be brought out more clearly after contrasting briefly the opposing views as to the method by which a species is modified.

Neo-Lamarckians, noting the undoubted modification of individuals through change of function caused by changed environment, *assume* that characters so produced are inheritable, and thus account for the gradual modification of a race to fit such changed environment.

Neo-Darwinians, regarding characters as developing almost wholly under the control of the internal factor (heredity) cannot conceive of acquired characters being inherited, because there is no way in which characters of the soma produced by the direct influence of the environment can produce such representative changes in the germ plasm. Changes which appear to arise because of increased function of certain organs to meet changed environment are really established as racial characters through natural selection acting on chance variations.

These two views are regarded as wholly mutually exclusive. Are they really so? Let us remember that what we call a *new* character is always the result of a change in the degree or direction of development of some previously

existing structure. Such modified development is taking place for a longer or shorter period, commonly at the *end* of the general development of the individual, that is, as the individual is reaching maturity. But this development is, as has already been set forth, the result of the interaction of an internal factor (heredity) and an external factor (environment); or in other words it is the reaction of the organism to external forces. Now, some individual organisms, as I have explained above, will react differently from others; or if we take the case where the external factor is a change in the environment necessitating increased function of some organ, some will react more favorably than others, and such variations occurring especially when needed, as above shown, will present many cases of a selective value even in the first generation. If this be so, natural selection will account for this perpetuation. Let us take, as a concrete example, the case of the long neck of the giraffe. Neo-Lamarckians would say that the efforts of the animal to reach high foliage causes the neck to grow longer, and this being inherited generation after generation, finally results in the present condition.

Neo-Darwinians would say that among many ancient giraffes some accidentally had longer necks, and these, getting more food in famine time, survived and perpetuated their kind; the selection of such chance variations from generation to generation resulting in the present condition.

The view here put forth is that among many developing giraffes, some, *by chance*, possessed such powers of growth that they were able to react better than others to the external factor, the stimulus of reaching up, and, as a result of this reaction their necks grew longer; *then* they came under the operation of natural selection.

Furthermore, I believe it can be shown that variations of the kind I have been discussing, namely, those which arise when the environment is gradually changed, will be *progressively adaptive;* that is, with each change in environment, variations will not arise indiscriminately in *all*

directions around the normal, but wholly or mostly *in a favorable direction.*

Let us illustrate this by the case of an animal that commonly escapes its enemies by virtue of its speed. If considerably speedier than the forms that prey upon it, it will always escape when it has a chance to bring its powers of flight into operation, and will be destroyed only by being surprised or in some other accidental manner; but if it differs but little in speed from its enemies the effort that it will have to put forth to escape in each case of pursuit will be inversely proportional to the amount of this difference. If its enemies in the course of generations increase their speed, the animal preyed upon will likewise be compelled to put forth greater efforts, and those individuals that are capable of responding best to this increased effort by an increase in the development or their muscles, will be the ones in each generation to survive. All the forces of the environment will therefore act to produce a variation in a desirable direction alone; while there will be in no case, even where the animal may accidentally be freed from the chances of pursuit, of any environmental forces acting to produce a physiological change that would result in a less degree of speed. In other words there is a progressive adaptation to the needs of the environment.

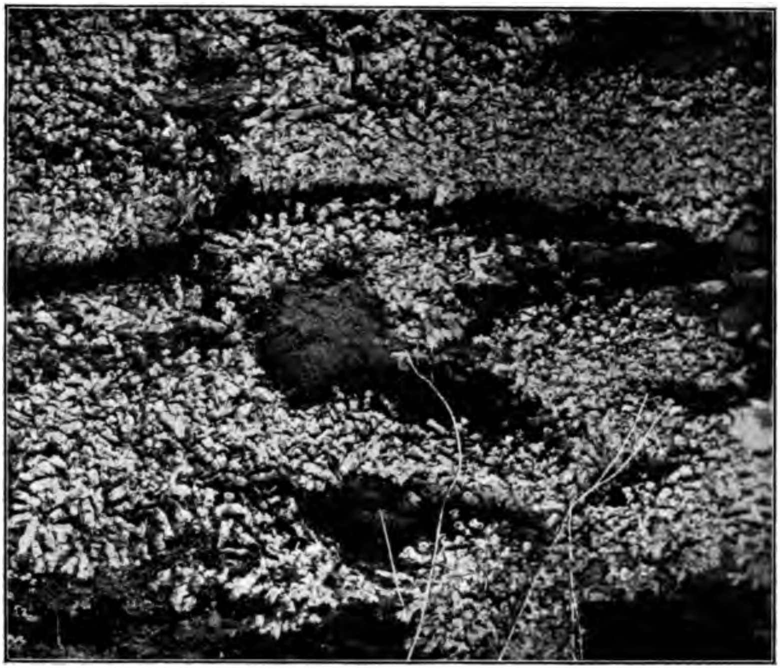
I wish to present still another thought in regard to forms in a new environment. We must remember that when a species is subjected to changed conditions, these changes are not likely to take place simultaneously over the whole range of the species. Those individuals that are capable of being modified little will be especially energetic in seeking out conditions as near as possible like the old ones; while those that become, by individual modification, adapted to the new conditions, finding here less competition from their kind than in the overcrowded, because less changed portions of the territory, will in consequence *prefer* these new conditions. Local segregations of easily modified individuals will thus occur, and by the interbreeding of these, their capability of modification will be accentuated. There will thus gradually arise a differentiation in

the species and the individuals which, by reason of their power of adaptation, have not made the effort necessary to seek out an environment similar to that in which their ancestors had been living, will give rise to a modified race of the species; this race will in most cases probably soon overshadow their less variable relatives because of the rapid increase rendered possible to them by small competition with other forms in the new environment. In other words we here have a method of isolation based primarily on the efforts of the individuals to seek a favorable environment, the result being polyphyletic evolution.

In conclusion, I wish to say that I have made no attempt to give a history of the different theories of heredity and evolution that have in the past been proposed, to be either ultimately accepted or rejected, but merely to select for discussion a few leading ideas upon which attention has been recently concentrated, and which seem to me to be in the direct line of probable further advances in our knowledge.

A section of Wisconsin drift in Lyon county, Iowa. The section shows a layer of bowlders accumulated immediately under the surface soil, here about a foot in thickness.

A lichen, *Lecidea albocœrulescens*, on sandstone at Wild-cat Den, Muscatine county. It distinctly prevents erosion of the rock.



A liverwort, *Asterella hemisphaerica* Beauv., on sandstone at Steamboat Rock, Iowa.

LIVING PLANTS AS GEOLOGICAL FACTORS*

BY B. SHIMEK.

The importance of water as a geological agent, both constructive and destructive, is so great and its effects are everywhere so patent, that by contrast the importance of other agents is underestimated, or in large part overlooked. Among these underestimated agents plants may be classed so far as their modern work is concerned.

It is not purposed here to discuss the geological value of plants as exhibited in various deposits, such as graphite, coal, limestone, diatomaceous earth, etc., but rather to note the work which is being done by living plants. Beyond the disintegration of rock by their acid rootlets and rhizoids, very little destructive influence is exerted by plants. They gather up much soluble material from the soils, but this is returned again upon the death and decay of the plants, and assists in the formation of the fine surface soils.

Each individual plant takes up but little mineral matter, but the amount so transferred to the surface by all the plants of a given area is worthy of consideration.

In a large part of Iowa, notably within the Wisconsin drift lobe, the soils are comparatively thin, and most higher plants send their roots through them into the underlying drift, from which they remove some of its soluble constituents. These are finally returned to the surface soil, but are then more or less distinctly separated from the coarser drift material with which they were formerly associated. In this manner plants have no doubt assisted other agencies, such as water, wind, and burrow-

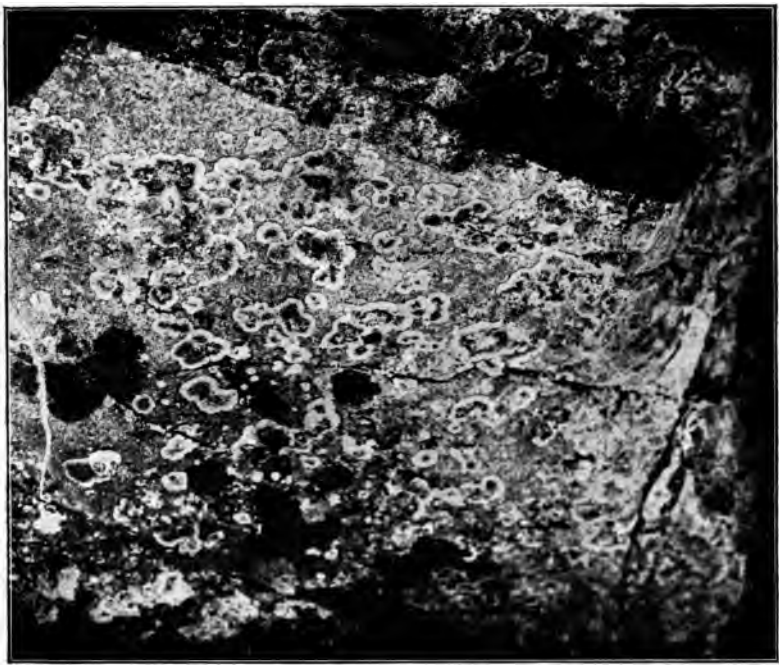
* The subject is here discussed with special reference to Iowa and adjacent territory.

ing animals, in that segregation of bowlders in the upper part of the drift and immediately beneath the fine surface soil, which is so noticable in northern and northwestern Iowa, especially within the Wisconsin drift lobe (Plate II).

From the very nature of their distribution and habits living plants affect chiefly the last, most recent, less compacted superficial deposits of the earth. Their influence is usually exerted so slowly that the immediate results are not striking, and never so pronounced as those sometimes produced by water. Nevertheless they are sufficient to warrant us in placing living plants among the most effective agencies concerned in the formation and transformation surface deposits of the earth.

It is commonly held that plants destroy the rock with which their roots come in contact, yet one of the most striking effects of their presence is the prevention of erosion. Friable rocks are often held together against the erosive action of air and water by surface coatings of lichens and liverworts. Upon the sandstone bluffs at Wild-cat Den, in Muscatine county, the lichen *Lecidea albo-cœrulescens* (Plate III), forms incrustations which finally stand out in relief as the surrounding sandstone is worn away, and similarly liverworts, such as *Conocephalus conicus* and *Asterella hemisphœrica* Beauv. (Plate IV), bind the grains of sandstones together by their rhizoids, and prevent erosion. Even much harder and more resisting rocks are often protected by plants. Thus lichens, such as *Rinodina oreina* (Ach.) Mass. (Plate V), and others, form incrustations upon exposures of the Sioux Quartzite in northwestern Iowa, and protect the rock from wind-driven sands in much the same manner that wax or paraffin protect glass surfaces from the sand-blast. The hard quartzite is usually highly polished upon the bare surfaces, while lichen-covered areas, equally exposed, protect the rock against the natural sand-blast to which they are so often exposed.

But this preventive power is more strikingly shown, as a rule, in the case of looser materials, such as loess and drift clays, residuary clays, soils, etc. If a surface of such



Lichens, chiefly *Rinodina oreina* (Ach.) Mass., on Sioux Quartzite, Lyon county, Iowa. The bare rock-surface around them is often highly polished by the wind-blown sand.

A loess bluff in Sioux City, covered in part with Russian thistles, grasses, etc., and with small cottonwoods and smooth sumach.

Loess bank on Burlington street, Iowa City, Iowa. A column of loess is held in place by the roots of a lilac bush, which have checked erosion.

material is freshly exposed, there soon appears upon the surface, especially if it be not directly exposed to the sun, a coating of some unicellular blue-green alga which holds the soil particles by its gelatinous sheath. Small mosses, and perhaps liverworts, such as *Marchantia*, follow, making the anchorage still safer by their numerous rhizoids. On the loess bluffs of western Iowa a *Nostoc* and a lichen, *Biatora decipiens* (Ehrh.) Fr., commonly perform this function. Then grasses, weeds, various flowering herbs, establish themselves, and finally shrubs and trees gain a foothold. A good illustration is furnished by the bluff at Sioux City, represented in Plate VI. Here the Russian thistle, various grasses, etc., represent herbs, while the cottonwood and smooth sumach are the forerunners of woody plants.

The writer has frequently observed this sequence of floras on loess banks which were protected from the sun, while exposed portions of the same bank were bare, and more or less eroded. Wet seasons, such as that of 1902, may give such plants an opportunity even in comparatively exposed places.

That trees and shrubs prevent erosion is well known, and some, such as willows, are planted along water-courses for this purpose. Plate VII furnishes another illustration. Here the roots of a lilac bush have held a mass of loess clay in a column, while the adjoining materials were eroded away. An upturned tree carries with it a mass of earth entangled in the meshes of the roots, and more or less agglutinated by the root-hairs, and such a mass as that in Plate VIII, will often resist the action of winds and rains for a long time.

In deep woods very little erosion takes place, partly because of the dissipation of rain-drops by the branches and leaves, and partly because the spongy leaf mould so rapidly absorbs the water which falls upon the surface. The result is that even in the deepest ravines with steepest sides even after the heaviest rainstorms the water runs clear, unclouded by the products of erosion. Once remove

the forest and every shower seams and scars the denuded hillsides.

But plants assist not only in preventing the tearing down of such deposits, but they often assist in building them up. That they serve as holdfasts for material carried by water is shown on every lake shore and along every stream in the state. Plate IX illustrates such a beach on the shore of Spirit lake. As the lake subsided in recent years the water receded, exposing the beach shown in the figure. Soon sedges and other beach plants appeared, and each wave that swept over them during storms, deposited more material, and the beaches were gradually elevated. Other plants, such as Artemisia, etc., then took possession of the higher, now dry beaches, and made possible the accumulation of a new soil from the materials washed down from higher grounds, or blown up from the beach. As this new soil was formed the more luxuriant vegetation of the higher shores gradually crept out upon the sandy beaches, until to-day such vegetation grows in abundance in places which within the memory of the writer were perennially covered with water.

Plate X, representing a low alluvial bar covered with vegetation, furnishes another illustration. Thirty years ago the main current of the Iowa river swept over the site of this bar. As the current shifted to the east a bar of sand and gravel was gradually formed on the west side. Only a few years ago this bar was almost barren of vegetation. Then sand-loving sedges and grasses appeared, and other plants—weeds especially—gradually took possession of the higher parts. The bar was periodically flooded, and each receding flood left more or less alluvium among the lowly plants on the bar. Then the sand-bar willow established itself, the accumulation of alluvium became more rapid, and that part of the bar became higher after each overflow, and finally only the higher floods were able to reach it. Then seeds of other trees were carried to it by wind and water, and the black willow, almond-leaved willow, black birch, white ash and cottonwood gained foothold. The lower part of the sand bar, next to the river,

White elm, Muscatine county. Although this tree had been up-rooted for some months, and exposed to an unusually wet season, the roots retained a large quantity of earth.

A Spirit lake beach with tufts of *Artemisia*, sedges, and other beach plants.

An old sand bar in Iowa City on the west side of the Iowa river. It shows three distinct terraces of vegetation, the one in the background being on the older alluvial plain.

remained covered with sedges and grasses for a time, but these too yielded to the sand-bar willow, which now extends quite to the waters edge. These terraces of vegetation may now be observed: the sand bar willows in the foreground; beyond them and rising above them, the taller black willow, white ashes and cottonwoods; and in the background the still taller elms, cottonwoods and other trees of the old alluvial plain. These three terraces of plants correspond to three terraces of soils, two of them built up out of a river bed within twenty-five years.

The beds of the lakes and ponds which were left by the retreating glaciers were also gradually covered with an accession of floras, each of which accumulated more soil, partly from waters and partly from winds, and thus prepared the way for its successor Such gradation of floras is still shown along some of the lakes and swamps within the Wisconsin drift lobe, and is illustrated in Plate XI. These lakes and ponds were formerly so abundant in the northern part of the Wisconsin lobe that that region was known to the early settlers as the "thousand lake region of Iowa," but within twenty years most of them have disappeared, and their beds are now covered with vegetation, native or introduced. Even the very wet season of 1902 was able to restore only a comparatively small number of these former lakes.

But not all soil has accumulated from water. Indeed, a very large part of it seems to have been carried to its present location by winds, and again plants served as holdfasts. The powerful influence of winds is demonstrated constantly in the sand hills of Muscatine Island, and of Nebraska, in the sand dunes of Lake Michigan, and by the dust storms along the Missouri river. Large quantities of material are transported by winds. In the northern part of West Point, Nebraska, several exposures show sand which has been carried over genuine loess, in one place to a height of sixteen feet. The writer was present when the roadway leading to the Bohemian cemetery in West Cedar Rapids, Iowa, was being graded. The excavation, which was made at the top of the high ridge, revealed a fence

buried in a layer of stratified sand not less than six feet deep, and which had certainly been deposited within thirty years, probably considerably less. It was certainly a wind formation. One need but observe the dust-storms of western Iowa and of Nebraska to be convinced of the motive power of wind.

The anchorage for material so carried is usually furnished by vegetation. During dry seasons, when vegetation is checked, sandy areas are likely to be extended over formerly fertile tracts. More favorable seasons or conditions which bring about a greater growth of plants cause an encroachment of vegetation upon the sandy areas, and as soon as this has taken place the shifting ceases, and new soil is soon formed. This has been especially well illustrated along the borders of the sand hills in Nebraska, and there are to-day large tracts serving as cattle ranges which, within the memory of settlers now living, were deserts of shifting sand.

That plants do hold loose material which would otherwise be swept away, is well illustrated in almost every field in Iowa in winter. If a field is plowed it is much more likely to be swept bare of snow than the adjoining stubble-field or weed patch, and in deep woods snow seldom drifts, but usually settles down in an almost uniform blanket-like layer. The effect upon dust is the same.

The best evidence now available indicates that the loess, so widely distributed in the Missouri valley, was deposited upon plant-covered land surfaces by wind. That plant life was abundant during the deposition of the loess is shown by the presence of terrestrial herbivorous molluscs, which were quite as abundant as the same species are to-day in the fauna of the plant-covered surface of the state. The same fact is indicated by the comparatively uniform thickness of the loess, which would not have been maintained if there had been no plant anchorage. In this connection it is well to note that the comparative uniformity and fineness of the loess materials, and the frequent distribution of terrestrial shells vertically through the deposit, give evidence that it was not laid down in

Edge of a pond near Okoboji, Iowa, showing drift surface with little vegetation.

A row of trees at Clear Lake, Iowa, partly buried in sand bank. The sand was evidently blown up from the adjacent beach.

Wind topography near Sioux City, Iowa.

bulk, but was a gradual accumulation such as would appear impossible in water in view of the extent and present topographic features of the region in which the deposit is found.

The influence of plants upon the formation of the loess is also suggested by the fact that the deposit is thickest on highlands, either adjacent to streams or along morainic lines. On these highlands terrestrial vegetation was first able to establish itself after the recession of the glaciers and while the lowlands were still covered by water at least a part of the year, and in such places taller vegetation has been able to maintain itself to this day, especially in close proximity to streams.

Such highlands would also lie near the chief source of supply of the fine materials, already discussed by the writer.*

Since the retreat of the ice-sheet our rivers have been subject to overflow, especially during the spring, after the melting of snow and ice. During the flood period large quantities of detritus have always been transported, and finally deposited in bars of mud and sand. During the summers the waters have subsided and exposed these bars to the summer winds. Most of the material taken up by the winds was deposited among the plants on the skirting hills, where it entombed the shells of terrestrial snails; some, especially the finer particles, was carried farther and deposited in part among the more lowly plants of the prairie, among which snails are seldom found. The morainic highlands were situated in much the same position. They were adjacent to streams in most cases, and sometimes to ponds and lakes which furnished very similar conditions.

Because loess was abundant along the borders of the Iowan drift it was concluded that glacial agencies played an important part in furnishing material for the deposit. The significance of this circumstance has probably been misinterpreted. If the border of the Iowan drift be traced from the Wisconsin margin in Hardin county to Scott

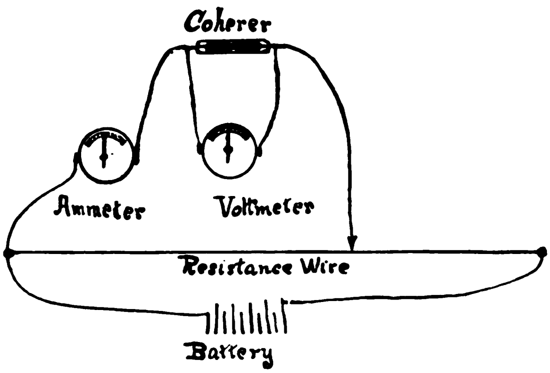
*See "The Loess of Natchez, Miss."—Am. Geol., Vol. XXX, pp. 295-6, 1902.

county, and thence northwestward to Howard county, it will be seen that it is nowhere distant from silt-bearing streams. The Iowa, Cedar, Wapsipinnicon, Maquoketa and Turkey rivers furnished the silt, while the adjacent highlands of the drift border furnished the necessary ecological conditions.

In the western part of the state vegetation is less abundant, the winds are much stronger, and the silt-bearing Missouri furnishes much more material, the result being that thicker and less regular deposits have been formed, and they commonly exhibit distinct wind topography, as for example, along the Missouri bluffs on the Iowa side. A striking illustration of this kind of topography may be observed above Missouri Valley, but the finest and most extensive area lies northwest of Sioux City (Plate XIII).

This area lies directly in the path of the dust-storms which frequently sweep across the broad Missouri bottoms from the southwest. To the observer watching the advance of one of these storms it is evident that the bars of the Missouri furnish a very large part of the dust, and he is not left long in doubt concerning its volume. But even in these western regions the formation of comparatively stable deposits would not be possible without the presence of plants, for they alone are able to anchor such fine materials.

We must certainly credit plants with constructive work, not only in the formation of alluvial deposits, but in the accumulation of finer soils and subsoils. It is customary to refer to new soils, such as those formed upon lava surfaces, as products of the destructive disintegrating influences of plants. The greater part of the soil so accumulated in most cases, whatever may be the facts concerning lava surfaces, is brought by wind and water from adjacent exposed surfaces, and is retained by the plant covering which is sure to appear sooner or later upon even the most barren surface.


Coherer
Ammeter
Voltmeter
Resistance Wire
Battery

SOME OBSERVATIONS UPON THE ACTION OF COHERERS WHEN SUBJECTED TO DIRECT ELECTROMOTIVE FORCE.

BY FRANK F. ALMY.

Most of the earlier quantitative work with coherers seemed to indicate that the coherer was uncertain or indefinite in its action. Some of the more recent work has, however, shown more definite and consistent results.

The measurements of Guthe and Trowbridge* on simple coherers subjected to sudden, direct electromotive force tend to show that the current through the coherer increases with the electromotive force in such a way that it would be represented graphically (using e and i as co-ordinates), by a smooth curve which in the limit becomes tangent to a line $e =$ constant. The curves representing the results of their experiments are without abrupt change of curvature.

On the other hand Kinsley†, subjecting a filing coherer to a continuously varied electromotive force finds "that the resistance remains unchanged, as the potential difference is increased until a certain value is reached, when the resistance suddenly falls."

In August, 1901, I undertook some measurements upon the behavior of coherers, subjected to a continuously varied electromotive force. The E. M. F. was obtained by a simple potentiometer (Plate XIV), by means of which it could be varied continuously from zero to any desired value. An ammeter was placed in series with the coherer and a voltmeter in shunt across its terminals. The current flowing

*Phys. Rev. 11, p. 22.
†Phys. Rev. 12, p. 177.

through the coherer and the potential difference between its terminals were read directly.

For the determination of the behavior under the smallest E. M. F.'s a high resistance, four coil Kelvin galvanometer was used as voltmeter and a similar low resistance instrument as ammeter. For larger E. M. F.'s these were replaced in turn by milli voltmeter and millammeter; voltmeter and ammeter. This range of instruments indicates the range over which the investigation extended.

It was my fortune to have the use of one of the filing coherers used by Kinsley in his investigation; a coherer with fixed silver electrodes, with silver filings slightly coated with silver sulphide. The amount of filings in the gap between the electrodes was capable of adjustment. On measuring the current flowing as the E. M. F. was continuously increased, the current was found to increase in such a way as to be represented graphically by a smooth curve. The relation between the E. M. F. and the current depends upon the initial conditions, viz: the amount of filings between the terminals and the pressure upon them. The several curves seem to be related in such a way as to be expressed by the equation.

$$i = af(e) \quad - \; - \; - \; - \quad (1).$$

in which i = current; e = E. M. F.

a = a variable parameter, depending upon the initial conditions.

Guthe and Trowbridge give for their results:

$$f(e) = \log (1 - e/E)$$

when E = the maximum potential difference that can be sustained between the terminals of the coherer.

Measurements were made upon a simpler coherer, consisting of a single contact between $\frac{1}{8}$ inch steel bicycle balls supported in a horizontal glass tube of slightly larger internal diameter. The balls were carried by spiral springs, one of which could be moved along the tube by a micrometer screw, in order to vary the pressure at the contact. The coherer was carried on an insulating base. This was floated in a vessel of mercury which in turn was floated in a second vessel of mercury. Connections were made

with the coherer through wires supported independently, dipping one into a mercury cup on the base of the coherer, the second into the vessel of mercury in which the coherer floated, and into which dipped a wire from one terminal of the coherer. The whole apparatus was supported on a stone shelf. The measurements resulted in a family of curves similar to those obtained for the filing coherer, the individual curve depending upon the initial condition of contact. It would appear that the curves given by the measurements of Guthe and Trowbridge, and those which would represent the behavior of the coherer as described by Kinsley are but widely separated curves of the same family. For, using the filing coherer with a very few filings in a very loose contact, the results conform to those described by Kinsley, while with a large number of filings more closely packed, there is very slight variation of resistance with increased electromotive force. Between these two extreme conditions, results which conform to the curves of Guthe and Trowbridge are easily obtained.

This conclusion is further confirmed by the work of Bose* and Eccles†, that has appeared since the above measurements were made.

If instead of representing the behavior of the coherer graphically in terms of current and E. M. F., we represent the conductivity (reciprocal of resistance) of the coherer as a function of the current flowing, the curve becomes a straight line. *A linear relation exists between the conductivity of the coherer and the maximum current that has passed through it.* This is expressed by the equasion

$$C = C_0 + Ei \quad \ldots\ldots\ldots\ldots\ldots \ldots (2).$$

where C = conductivity of coherer.

C_0 = constant depending on initial conditions (initial conductivity).

i = Maximum current that has passed through the coherer.

E = constant — corresponding to the maximum E. M. F. that the coherer can sustain.

From the series of simultaneous readings of voltmeter and ammeter the resistance of the coherer was calculated:

* Electrician, August 30, 1901.

† Electrician, August, 1901.

from that its conductivity was determined. In all cases, except for the initial part of the curve, the conductivity is a linear function of the current. In the initial part of any curve the scale readings of voltmeter and ammeter, beginning at approximately zero, were small, and the probable error in them and in the conductivity determined from them is correspondingly large, and consequently the values for this part cf the curve are somewhat indeterminate. This remark applies equally to the curves determined when the E.M.F. and current were of the order of magnitude measured by the galvanometers or by the voltmeters and ammeters. I have considered in the same way the results of Guthe and Trowbridge, Bose, and Eccles, and find the same relation to exist between the conductivity and current, except in the results of Eccles. In that case it is not certain that the resistance obtained from his tabulated values of E.M.F. and current is the resistance of the coherer alone. The departure from the law is such as to indicate that this is not the case.

It is interesting to note that the conductivity of dielectrics (parofine and guta percha) as deduced from the measurements of Leich* increases with the current flowing through them in such a way as to be represented by a straight line. Also that Ayrton and Perry† found the potential difference between the two carbons of an arc lamp was independent of the current strength provided the distance between the carbons was kept constant, or in other words, the apparent conductivity of the arc varies directly as the current. Shaw‡ has shown that after the electrical coherence or fall of resistance there is cohesion.

The resistance does not increase again after the current ceases to flow, unless the coherer is subjected to stress. The resistance after lowering is not affected by a current smaller than that which produced the lowering.

All these results seem in harmony with the theory of the coherer as advanced by Guthe and Trowbridge, that "as the current flows, ions from the positive electrode

* Wied. Ann. 66, p. 1107.
† Phil. Mag. May, 1883
‡ Phil. Mag. Mar., 1901.

break through the film, forming metallic contact, thus reducing the resistance," and that this takes place until a bridge of metallic particles is formed of such a cross section as to have a maximum carrying capacity equal to the current impressed.

Lodge* considers coherence to be of the nature of a welding together of the surfaces, and has been interpreted by later observers as considering the fall of potential due to the formation of a metallic bridge between the particles, "especially if the electric stimulus acted in any way as a flux by reducing the infinitesimal tarnish of oxide or other compound which must be supposed normally to cover them." It would seem that this conception might be possible if one considered the fluxing to be electrolytic.

* Phil. Mag. 37, p. 94; Electrician, 40, p. 87.

THE ACCRETION OF FLOOD PLAINS BY MEANS OF SAND BARS.

BY HOWARD E. SIMPSON.

About one-half mile above the confluence of the Iowa and Cedar rivers, the Iowa makes a great bend from a southwesterly to a southeasterly direction. The river on the outerside of this curve is rapidly cutting at the base of a high bluff for a distance of about one-third of a mile. The bluff extends beyond at each end, bounding the flood plain, but at some distance from the stream. The bluff is composed chiefly of Kansan drift overlain by Iowan loess, which creeps rapidly riverward when saturated with water.

Opposite the bluff the broad flood-plain and level "bottoms" extend away eastward to the drift hills beyond the Cedar and to the northward merge into the sandy floor of ancient Lake Calvin.

The work of the river in cutting down the higher land and widening its flood plain is plainly shown on the face of the bluff where the process has been very rapid during the past season. Many yellow scars indicate the creep of land rapid enough to cause landslips, and at intervals masses of soil fall into the water and are carried away by the current, a single mass having carried four oak trees rooted in it.

Farther evidence of the retreat of the bluff may be found at the summit, where the very edge forms the divide between the river and its tributary, Short creek, so great has been the shifting. An Indian burial mound known in local tradition as "The Grave of Osceola's Queen," has practically disappeared within the memory of living set-

tlers and the charred trunk of an ancient oak, a well known landmark, now stands with roots half in air.

Two years ago last September the peculiar form of an island, near the inner side of this bend, attracted my attention. It was perhaps 230 feet long, crescent shaped, with points turning toward the flood plain side. A heavy growth of willows covered the main portion, indicating in a general way the age of the island. These dwindled away toward the lower end and the points of the crescent were of soft newly deposited silt. A very slow drift of water was noticeable on the inner side while on the outer, well over toward the base of the bluff, swept the main current.

Observing this island in the following May, it was found that the horns had grown to such an extent that they were both connected with the inner bank and entirely enclosed a small lagoon of stagnant water. In October, 1901, one year after the first observation, the lagoon had entirely disappeared and a barren strip of sand marked its former position. The willow covered island was now a part of the flood plain. The process was probably hastened by the extreme drought of the season and the consequent low stage of water in the river.

The past spring of 1902 found grass and weeds growing over the greater portion of the former lagoon, and all trace of former island would soon have been lost in flood plain had not the excessive rains of last July and August flooded the bottom lands and removed a small amount of the filling of the old inner channel, leaving a small, stagnant pool, surrounded with the tangled growth of willows and weeds of the flood plain.

Observations on other islands in the Iowa and Cedar rivers, and in the Mississippi between Lansing and Muscatine, lead me to believe that this island is not a peculiar form, but a type which is well defined and frequent enough in occurrence to deserve recognition. The history of its development from sand bar and flood plain may be sketched in the following three stages.

A lodged snag or other obstacle in any well loaded stream may check the current, leaving a small area of com-

paratively quiet water on the down stream side. Around and into this from each side come eddies, bearing sediment in suspension which lose their swiftness, drop their load and thereby start a sand bar. This bar develops by additions mainly on the down stream end, but also on both sides.

The deflection of the current by the obstruction turns the stronger current slightly against shore and tends to start a meander, leaving the island on inner side of curve and increasing deposit.

The swifter eddy swinging from the side of the stronger current, deposits in a curve from the lower end and shoreward on the opposite side. A tendency to stagnation, therefore, results on that side and causes a deposit in a curve from the upper end along the edge of the current. The sand bar thus becomes crescent shaped and the first stage is ended.

In the second stage the silting goes on rapidly until the horns of the crescent reach the shore and enclose a lagoon of stagnant water.

During the third and last stage the lagoon is filled up as are other flood plain lakes, by direct deposit of sediment from winds and high water, and by plant encroachment, until all trace of the lagoon is lost and the island has been added to the flood plain.

The study of the single island, together with the observations on others in all stages of the process described leads us to the conclusion that it is a type common to valley and plain tracts of rivers, and that flood plains receive definite accretions by means of sand bars.

SOME ECOLOGICAL NOTES ON THE VEGETATION OF THE UINTAH MOUNTAINS.

BY L. H. PAMMEL.

The Uintah range of mountains extends in a northeasterly direction from the Wahsatch range to Green river in eastern and northeastern Utah.

In the range occur types of plants from the southwest, the boreal types of the mountains further northward, many forms from the main Rocky mountain flora, besides prevailing forms west of the continental divide.

The geological and physiographic features of the region embraced by the Uintah range and the surrounding territory of southwestern Wyoming, northwestern Colorado and northeastern Utah are of especial interest, and have been fully treated by White[1], Powell[2], Hayden[3], King[4] and others.

Tributary to the Uintah range are two arid basins. The Green River basin is flanked on the south by the Uintah mountains and foothills, Green river receiving the drainage of those mountains. The eastern portion of the basin is skirted by the foothills of the Park range of the main Rocky mountain range. South of the Uintah range is the Uintah basin or the great plateau basin of the Colorado. Clarence King, in speaking of this basin, says: "The general configuration of the Green River area is that of a rude triangle, having the Uintah system as the base, the

[1] On the geolology and physiography of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming. Rep. U. S. Geol. Survey, 9: 683.

[2] Geology of the Uintah mountains. Exploration of the Colorado river of the West and its tributaries.

[3] Sixth Annual Report of the United States Geological Survey of the Teritories, 15: 192-208.

[4] Systematic Geology. United States Geological Exploration. Fortieth Parallel.

Wahsatch as the western side, and the great Wind river range, with the westward members of the Rocky mountain chain as its eastern boundary." It is a great plain intersected by numerous canons, the whole having a desert aspect. Every part of this basin has an altitude of more than 5,000 feet. A portion of the Uintah basin, on the other hand, has an elevation of less than 5,000 feet. The desert features on the south side of the range in the Uintah basin are even more marked than on the north side. The red Jurassic sandstone is intersected by deep canons. These contain no perennial streams between Ashley creek and Farm creek to the west. The only tree found here is the western cedar (*Juniperus occidentalis* var *monosperma*), and an abundance of *Artemisia tridentata*, with the associated desert herbaceous plants. The shorter tributaries of Green river rising in the foothills carry water only during the spring months; in July and August the water stands in small pools. The tertiary plateaus which may be seen as escarpements along Green river and all of the larger tributaries, rise from 200 feet to 700 feet above the flood-plains of the streams.

These plateaus likewise support a desert vegetation, although towards the foothills shrubs like *Amelanchier alnifolia* and *Symphoricarpos* grow in greater abundance than along Green river. From the base of the tertiary plain, through a series of gentle rises, the foothills and mountains may be approached. The long parallel ridges on the south side are less marked than on the north slopes of the mountains.

Clarence A. King in a terse paragraph describes this range as follows: "The only one of the great boundary mountain ranges that encompass the Green River basin is the Uintah range which forms the southern barrier to the basin. It is an immense single mountain block about 150 miles long, having an average elevation of 10,000 to 11,000 feet, and rising at its culminating point, Emmon's Peak, to 13,694 feet. It is defined both on the north and on the south by tertiary table-lands which abut unconformably

1. c 9

Fig. 1. The mountainside covered with yellow flowered *Bigelovia Douglasii*, here and there *Ribes aureum*, and *Stanyleya pinnatifida*.

Fig. 2. *Mentzelia ornata* removed from a calcareous shale shown in Fig. 1.

against its steeply inclined strata. As a range it is unlike any other in America, being in fact a great lofty plateau of nearly horizontal strata, which at the north and south edges are sharply broken and thrown into highly inclined portions. * * * The upper plateau region is deeply carved by the erosion of the glacial period into a network of immense amphitheaters opening downward into a series of ice-worn canons. * * * It is a type of mountain architecture only paralleled by the uplands of the Caucasus." Perpetual snow occurs on the north side of more than thirty peaks, with a rich alpine vegetation in the meadows below the snowy banks. The high table lands above the timber line become dry soon after the disappearance of the snow. From the xerophytic table-lands one can see the foothills and mountains covered with a belt of coniferous woods, with opening xerophytic parks, numerous lakes and meadows just below the timber line. Altogether it is a region rich in its floristic aspects.

The xerophytic vegetation of the Uintah mountains varies with the different physiographic conditions and geological formations. From Green river basin to the summits of Gilbert, La Motte and Wilson Peaks, one naturally expects a very varied flora, because of the different altitudes. Up to 9,500 feet the Green river basin and Black's Fork, have some plants in common. The succession of plant societies in this region is well marked, and gives us on the whole the history of the succession of plant life since the quarternary.

The foothill and mountain floras change successively from the hydrophytic to mesophytic, then to xerophytic, and finally in the foothills culminates in the mesophytic, interspersed with a few hydrophytic areas. The varying conditions cause structural adaptations of the plants to their environment.

I shall attempt to give very briefly some of the main features of this interesting flora.

GREEN RIVER BASIN.

The temperature during the day is uniformly high; the heat is greater than the aerial thermometer indicates, owing to great amount of radiation from the earth. So that any plants occurring here must conserve moisture. The soil is parched and dry during the summer and late spring, because of its alkalinity.

The vegetation of the broad flood plains of Green river, in the vicinity of Green river, is essentially xerophytic. A few scattered groves of *Populus angustifolia* occur in the more favored situations.

The shrubs and herbaceous plants are more or less scattered. The soil is characterized by its tenacity when wet and baked, when dry with a white, alkaline efflorescence on the surface. The most abundant grass of the flood plain is *Distichlis spicata*. The widely distributed *Hordeum jubatum* and the western *H. caespitosum* are common and gregarious species of the lowlands. The *Distichlis*, owing to its habit of growth, spreads over the surface, to the exclusion of all other vegetation.

Two capparidaceous plants are common in the open places, *Cleome integrifolia* and *C. lutea*. both species, owing to their somewhat fleshy leaves are well adapted to this region. These species flower during the entire season. The *Stanleya pinnatifida* is associated with *Cleome*. *Atriplex longifolia* occurs in scattered bunches over the entire flood plain. A further special feature is the occurrence of other chenopodiaceous plants like *Sarcobatus vermiculatus*, *Chenopodium Fremontii*, *C. rubrum*, *Eurotia lanata* and *Suaeda depressa*.

During the spring of the year the lateral channels contain water, but in July and August these channels are dry. Here an abundance of *Hordeum caespitosum* occurs with a scattered growth of *Helenium autumnale* and *Potentilla Anserina*. The *Helenium* is usually not more than a foot high.

Along the immediate shore lines of the river in the cottonwood groves, *Glycyrrhiza lepidota*, *Symphoricarpos racemosus*, *Rosa Fendleri*, *Aster* and *Erigeron* usually grow in

Fig. 1. A small Blue Spruce swamp (*Picea pungens*), in the foreground *Cnicus scariosus* and *Potentilla fruticosa*. In the background *Salix curtiflora* and *S. cordata*.

Fig 2. A group of Blue Spruce in a swamp with a low creeping Juniper, *Juniperus communis* and *Arctostaphylos Uva-ursi*. A stump of an old red cedar, *Juniperus occidentalis*, on the border *Elymus condensatus*, on Black's Fork, 8,000 feet.

abundance. Under the calcarous rocks, close to the river's edge, a few mesophytic willows, *Salix longifolia S. amygdaloides* and *Pyrus sambucifolia* occur. The*Rosa Fendleri*, *Amelanchier alnifolia*, *Rhus Canadensis* var *trilobata* are also found in similar situations, but more commonly on the drier soil above, especially true of the *Amelanchier* and *Rhus*.

The dry bench land above the flood plains receiving the full rays of the sun show a temperature rising to 115°-120° F. during the day. Only plants that can endure long periods of drouth with a minimum transpiring surface are able to grow. It is the region of *Mammilliaria*, *Echinocactus* and *Opuntia*, but these by no means make up the bulk of the vegetation.

The *Cleome integrifolia*, is evident everywhere along the roadsides, and an occasional patch of *Agropyron occidentale*, with an abundant growth of *Iva axillaris* are characteristic plant features of the lower belt, The vernal plants, no doubt, are much more numerous, but their flowering period is so short that they could not be recorded at this time of the year. The upper area is cut by narrow and short canons, well characterized by the abundance of *Artemisia tridentata*, *Bigelovia* and the silky canescent *Artemisia frigida* forming more or less flattened masses on the ground. The spiny composite shrub *Tetradymia Nuttallii* with terete branches, narrow, small leaves, covered with a hairry tomentum, is well suited for this arid belt. Another spinescent composite plant is associated with it the *Artemisia spinescens*, occasionally also the *Antriplex longifolia*, *A. canescens*, and *Sarcobatus vermiculatus*. The introduced *Salsola Kali* var *tragus* is common at the mouth of the canons. With a few exceptions the plants are either fleshy or hairy.

THE UINTAH FOOTHILLS.

I shall confine my remarks in this paper to the flora of Black's Fork, but the general features of the flora are applicable to nearly all of the valleys on the north side of the range. The general trend of Black's Fork, Smith's

Fork and Bear river is northward, in Utah, but on the approach of Wyoming, flow northeasterly and then due east and southeast into Green river, excepting Bear river, which flows northward, around Bear lake, finally emptying its waters into Salt lake. The valleys have been carved out of the horizontal strata. The lower ends of the foothills are marked by high semi-arid table-lands, with an entire absence of trees, except on the slopes. These table lands are cut with canons in which a few shrubs like *Amelanchier alnifolia*, and *Symphoricarpos racemosus* are types.

The slopes usually contain a sparse growth of the western cedar (*Juniperus occidentalis* var *monosperma*). The ends of these table lands are frequently more conspicuously elevated and are called buttes. The Bridger Butte is a good illustration of the type of formation occurring in this section. Tenacious clay and broken fragments of the Green river beds and the brown sandstone of the Bridger group characterize the region.

From the river bed of Black's Fork to the summit of the table land a series of distinct flood plains occur, showing a well marked progressive change in the character of the vegetation. The limit of coniferous woods northward along Black's Fork is 8,500 feet. The limit of the aspen (*Populus tremuloides*), is somewhat lower, extending for some distance beyond the *Pinus Murrayana* belt. Beyond these open table lands the country is cut with longer canons, but it is possible to reach the source of the streams by an easy ascent to the high table lands at an elevation of 10,000 to 11,000 feet.

Near the old Ft. Bridger military reservation there are three well-defined flood plains. The present flood plain is an area abounding in trees of a mixed growth of conifers and deciduous trees. It is essentially a mesophytic area, with small hydrophytic basins, the current of the stream being so rapid in most places that few of the higher hydrophytes can find lodgment. It is only through the seepage of water in the smaller channels that these can find favorable conditions for growth, or in the small streams coming

Fig. 1. *Cnicus scariosus* on the open, moist plains frequently containing an abundance of alkali. The thistle is accompanied by *Hordeum jubatum* and *Ranunculus flammula* var. *reptans*.

Fig. 2. *Erigeron macranthus* Nutt. A common Fleabane among the bowlders, Black's Fork flood plain, 9,000 feet.

Fig 1. Burnt over district on a branch o° Bear river, Stillwa'er canyon. A young growth of *Pinus murrayana*. *Zygadenus elegans*, and *Epilobium spicatum* common everywhere in such places.

Fig. 2. Engelmann spruce woods near timber line, between 11,000 and 12,000 feet on Middle Black's Fork, below LaMotte peak. *Vaccinium cæspitosum*, *Trifolium Parryi*, and *Ribes lacustre*. var. *parvulum*, Erigeron, &c.

rom the numerous springs. The more conspicuous trees found here are *Picea pungens, Populus angustifolia, P. tremuloides, Betula occidentalis*, and *Almus incana* var *virescens*. A good undergrowth of *Thermopsis montana, Salix* sps. *Geranium Richardsonii, Vicia Americana, Gemu macrophyllum, Alluim brevistylum, Agropyron Richardsonii* and *A. pseudo-repens* is found here.

The mesophytic area is decidedly irregular. The second flood plain presents a series of irregular open parks, containing scattered groves of *Picea pungens*, a few groves of *Populus angustifolia* in the more moist situations, scattered trees of *Juniperus occidentalis* var *monosperma*, but the most conspicuous plant is *Artemisia tridentata*.

This belt is essentially xerophytic, and has been evolved from the mesophytic. The surface soil is a sandy loam; lying underneath are bowlders of various sizes. Very little humus remains, owing to the repeated washings of spring freshets.

The more common herbaceous plants found here are as follows: *Cnicus Drummondii* var *acaulescens, Antennaria* sp., *Campanula rotundifolia, Agropyron occidentale, Eriggonum umbellatum, Elymus condensatus, Stipa viridula, Lupinus argophyllus, Penstemon* sp. The *Populus angustifolia, Potentilla fruticosa, Juniperus communis, Arctostaphylos, Uva-ursi*, are remnants of an area once densely wooded like the present flood plain. Along the shorelines of this flood plain are springs, receiving their water from the third flood plain and table lands. The water in these springs is uniform during the season and registers 49° F.; these springs contain many hydrophytic species like *Spirogyra, Veronica Americana, Ranunculus Cymbalaria, Mimulus Jamesii* on the edge, *Cattabrosa aquatica* and *Carex*. These springs are always bordered by willows. More complete drying of the bench lands above, by a smaller amount of snowfall during the winter would destroy the present mesophytic vegetation bordering on these springs and turn it into a xerophytic park with its *Juniperus* and *Artemisia*.

The third flood plain forms a wide valley, treeless, except where intersected by streams. This area is marked by

only a few shrubs like *Symphoricarpos racemosus*, a few *Prunus demissa* and a great deal of sage brush (*Artemisia tridentata*), the plant growing from four to six feet high. The sage brush is naturally scattered, and around the base of the branches grasses like *Stipa comata*, *S. robusta* and *Agropyron occidentale*, occur. In the open places *Orthocarpus*, *Castilleia*, *Erigonum umbellatum*, *Lupinus argophyllus* are abundant; also two species of *Bigelovia*. Rising from the third flood plain there occurs what is commonly called a bench. These rise several hundred feet above the flood plain. The benches generally contain few shrubs or trees, except where the timbered belt begins. They are cut by narrow canons whose sides contain such shrubs as *Amelanchier alnifolia*, *Rosa Fendleri*, *Acer glabrum*, *Cercocarpus parvifolius*. Groves of *Populus tremuloides*, and occasionally, near the timber belt, *Pseudotsuga Douglasii*. Near the bases of these canons alkaline springs occur. *Salix Mackenziana*, *S. Bebbiana* are usually common in such places, accompanied by such plants as *Aconitum Columbianum*, *Aster*, *Erigeron*, *Bromus Porteri*, *Plantago*, *Phleum alpinum*, *Mimulus Jamesii*, and *Castilleia*. The slopes of these benches likewise contain the *Amelanchier*, *Cercocarpus*, and where the benches are dry, *Juniperus occidentalis* var *monosperma*.

During our stay at this camp the temperature was by no means excessive. The highest temperature recorded from July 11th to 14th was 95° F. The highest soil temperature, two inches down in the soil on the second flood plain, was 69.5° F. The highest record for the third flood plain was 85° F. At a depth of one foot in the third flood plain the highest record was 68° F.; on the third bench it was 78° F.

The marked conditions of the flora of Black's Fork at an altitude of 7,500 feet is as follows: First a mesophytic willow formation consisting of *Salix stricta*, *S. lutea*, *S. cordata* and *S. lasiandra* var *caudata*, *Populus tremuloides*, *P. angustifolia*, *Alnus incana* var *virescens*, *Betula occidentalis* and a small number of hydrophytic species. This constitutes the most recent formation. This is succeeded by

Fig. 1. Sage Brush (*Artemisia tridentata*), common on the bench lands above the flood plains of the streams, on Black's Fork.

Fig. 2. *Tetradymia Nuttallii*, a spinescent composite shrub, growing with sage brush and greasewood.

Fig. 1. *Lupinus argentens* in a relatively moist situation with *Cnicus eriocephalus*, between 9,000 and 10,000 feet. Black's Fork.

Fig. 2. *Primula Parryi* 12,500 feet, coming up between the crevices of rocks. The granitic rocks are covered with lichens, LaMotte peak.

xerophytic openings in which *Juniperus occidentalis* var *monosperma*, small groves of *Picea pungens* with an undergrowth of *Ribes cereum*, *Shepherdia Canadensis*, *Arctostaphylos Uva-ursi*, *Juniperus communis* var *alpina*, and *Potentilla fruticosa*, but the greater portion of the area consists of a rank growth of *Artemisia tridentata* and *Bigelovia Douglasii*. The Giant Lyme grass (*Elymus condensatus*), *Agropyron occidentalis*, *Stipa* sp., *Eriogonum umbellatum*, *Cnicus Drummondii* var *acaulescens* are common plants. The second flood plain may, therefore, be designated the *Juniperus* belt.

The third floor plain is much older than the first and second, and as the chief plant is sage brush, can be designated the *Artemisia* zone. In this belt the *Artemisia* reaches its greatest perfection. This area is entirely devoid of trees, and the only shrubs occurring are *Artemisia*, *Symphoricarpos* and a few *Amelanchier* and occasionally *Rosa Fendleri*. The *Eriogonum umbellatum*, *Artemisia*, *Orthocarpus*, and *Stipa* are some of the more conspicuous herbaceous plants. The fourth zone occupies the high table lands or benches. The absence of trees, except on the sides of the benches is characteristic. *Artemisias* are abundant, and also *Eurotia lanata*.

On ascending the stream the mesophytic *Salix* belt continues without interruption, except for the small xeophytic parks. The second or *Juniperus* belt continues up to an altitude of 7,800 feet, where the *Juniperus* is is replaced by an occasional grove of *Pinus Murrayana*; aside from this, *Artemisia* is a predominating type. The third flood plain or *Artemisia* belt is very much broken up at an altitude of 7,800 to 8,000 feet, forming hills intersected with undulating hills and depressions. *Picea pungens* and *Pinus Murrayana* and *Pseudotsuga* occupy portions of the hills. The fourth zone is occupied by scattered groves of *Populus tremuloides*, *Pinus Murrayana*, and *Picea pungens*, such shrubs as *Amelanchier alnifolia* and *Rosa Fendleri*. The *Artemisia* is less frequent on the flats and the *Eurotia lanata* entirely absent. There are, however, extensive belts of *Artemisia* on the sloping ridges.

The *Wyethia amplexicaulis* covers large areas in the open parks between the *Pinus Murrayana* woods, with several species of *Aster* and *Erigeron*. A species of *Helianthus* and *Arenaria Fendleri*, *Potentilla glandulosa*, *Erigeron glabellus*, and *Achillea millefolium* are all abundant, either in woods or in open places.

At 8,500 feet the glaciated area begins. The *Salix* mesophytic area continues with smaller xerophytic parks. The second flood plain contains arid belts, the chief plant being *Artemisia tridentata* and a species of *Bigelovia*, broken up, however, by small watered canons. The shores contain not only mesophytic plants, like *Populus tremuloides*, and *Salix pellita*. but a good growth of hydrophytes in the bogs. Conifers like *Abies subalpina* and *Pinus Murrayana* are increasingly abundant. The upper zones are no longer recognizable. They are cut up with small canons, and numerous small lakes, many of the latter without an outlet. Three trees are common here, *Populus tremuloides*, *Abies subalpina* and *Pinus Murrayana*.

Just above the junction of east and west Black's Fork, at an altitude of 9,200 feet, both streams have cut through a glaciated debris of 100–150 feet; the benches are extremely dry except where small streams have cut through. The vegetation of the benches is xerophytic. as well as the moraines. The first flood plain is essentially mesophytic, abounding in willows, like *Salix chlorophylla*, *S. macrocarpum*, *Thalictnone alpinum* and *Betula glandulosus*, but there are small xerophytic openings. The soil of these areas consists of coarse sand, with a little humus on the surface.

Artemesia tridentata is the most characteristic plant, with large, spreading mats of *Arctostaphylos Uva-ursi*, a few *Berberis repens* and such herbaceous plants as *Eriogonum umbellatum*, *Arenaria Fendleri*, *Castilleia miniata*, *Achillea Millefolium*, *Campanula rotundifolia* and *Frasera speciosa*; of the trees an occasional *Pinus Murrayana* and *Populus tremuloides* occur. Both of these species, however, occupy the depressions where water is more easily accessible.

The high and steep walls of the stream are covered with sage brush, *Artemisia tridentata*, *Erigeron glabellus*, *Campanula rotundifolia*, *Castilleia miniata*, *Antennaria sp.*, *Achilleia Millefolium*, *Stipa* and rarely a few shrubs like *Ribes* and *Arctostaphylos.*

The broken parks above the flood plain contain, on the border, small groves of *Pinus Murrayana*, in which *Astragalus alpinus*, *Pachystima Myrsinites*, *Arclostaphylos Uva-ursi* and *Juniperus communis* var *alpina* occur. The open, rough, hilly park contains *Potentilla Hippiana*, *Eriogonum umbellatum*, *E. ovaalifolium*, *Arenaria congesta* and *Castilleia miniata.* The chief constituent of the vegation, however, is the Artemisia and scattered bunches of *Bigelovia*, dwarf *Erigeron*, *Aster*, such grasses as *Agropyron* and *Stipa.*

Between the east and west fork, above the junction of the two streams, the area is covered by groves of *Pinus Murrayana* and open xerophytic parks; a small, well watered stream flows along the western shore of an ancient lake, now in part park, meadow and forest covered. The shore lines of this lake are twenty-five to fifty feet above the small stream. The oldest shore lines are marked by a coarse gravel and rounded boulders. The soil is extremely dry. In this dry soil large areas are covered with *Campanula rotundifolia*, *Cnicus Drummondii* var *acaulescens*, *Arenaria congesta*, *Orthocarpus*, *Geum triflorum*, *Potentilla Hippiana* and *Artemisia.* The greater part of the present area of this was once a meadow.

Passing up to higher altitudes between 9,500 feet and above, the sage brush generally disappears, although there are some exceptions. The sunny, dry slopes on Smith's Fork, and elsewhere, there are well defined belts of *Artemisia tridentata* at an altitude of over 10,000 feet. Between 9,500 and 10,000 feet on Black's Fork, the river has cut through a limestone formation, which extends through the entire range. At Smith's Fork the Bear and Weber rivers, the limestone rock is cut in the same way, and the water runs over the rocks, forming falls. In the deep canons, at these points, the hydrophytic plants are especially marked, and one finds here such types as *Vero-*

nica Americana and *Mimulus Lewsii*. Along the banks of the streams *Primula Parryi* and *Aquilegia caerulea*, the *Mertensia Sibirica*, often forming great festoons over the banks of the stream, and with it in the little bogs we find *Saxifraga punctata*, *Aconitum Columbianum*, *Trollius laxus* and *Caltha leptosepala*, with *Juncus*, *Salix macrocarpum*, *Gentiana heterosepala*, *Swertia perennis* and *Erigeron glabellus*. Mosses are numerous, of grasses *Phleum alpinum*, *Deschawpsia* and *Poa epilis*. In the drier portions of these canons, as well as the marsh, the *Picea Engelmannii* and *Pinus Murrayana*, but especially the *Picea Engelmannii* occur. In still drier situations the *Pinus Murrayana* and *Abies subalpina*, *Vaccinium caespitosum*, *Pachystima Myrsinites*, *Arctostaphylos Uva-ursi* and occasionally the *Ledum glandulosum* occur. The *Vaccinium caespitosum*, *Rubus strigosus*, *Arcoostaphylos* and *Ribes divaricatum* var. *irriguum*, *Trifolium Parryii* and *T. dasyphllum* and *T. longipes* are common in the Engelmann spruce belt. The clovers and *Ribes*, Rubus and huckleberry occur up to timber line.

At the timber line we have a large aggregation of plants that have a short blooming period; the soil is moist when the sun disappears, and we have Alpine gardens formed. Of these plants we may mention *Omphalodes*, *Geum Rossii*, *Acquilegia caerulea* dwarf form, *Dodecatheon media*, var. and *Primula Parryi*. At very high altitude *Salix reticulata*, *S. Artica* var, *petraea*, *Parrya nudicaulis* var. *glabra*, *Draba streptocarpa*, *Polemonium confertum* and several species of *Saxifraga* like *S. nivalis*, *Silene acaule*, *Erigeron* and *Erigonum*. The dwarf *Picea Engelmannii* and *Abies subalpina* are common above the timber line. The Engelmann spruce extending up further than *Abies subalpina*. The short blooming period protects these plants from the dry conditions that prevail later, the seeds ripen and mature in a short time. Most of the plants have a strong root stock which protects them not only from the drouth, but from the cold of winter

Fig. 1. An irrigated flat on Kamas prairie between Provo and Weber river. *Juncus Balticus*, *Deschampsia cæspitosa* are characteristic plants.

Fig. 2. Between 9,000 and 10,000 feet upon Black's Fork. *Pedicularis Grœnlandica*, *Deschampsia cæspitosa*, *Gentiana serrata*, *Phleum alpinum* and *Salix macrocarpum*.

Dwarf Engelmann spruce (*Picea Engelmanii*), between 12,000 and 13,000 feet, near the head waters of East Black's Fork.

THE MEMBRANE BONES IN THE SKULL OF A YOUNG AMPHIUMA.

BY H. W. NORRIS.

The specimen upon which the following description is based was 51 mm. in length. In the state of development of the skull it appears to be intermediate between the two stages described and illustrated by Winslow with figures of wax models. The chondrocranium appears to be almost exactly like that of the older specimen described by him, except that the ossification in my specimen is less advanced. The specimen was sectioned and a reconstruction of the skull was made after Born's method.

THE CRANIUM.

Ethmoidal Region. Of the bones found in the adult in this division of the skull only the nasals are wanting at this stage of development. The premaxilla has essentially the adult form described by Wiedersheim and by Hay. Along the border of the alveolar process of the premaxilla are about thirty teeth, of which ten are attached to the bone, five on one side and four on the other, with an unpaired tooth in the middle. Mention should be made here of the small unpaired cartilage situated in the roof of the mouth ventral to the palatine process of the premaxilla. Hay's theory is that "the anterior lobes of the trabecular cornua * * * grow downward until they meet below the palatine process and then coalesce." Afterward the part below the plane of the vomers becomes cut off and forms the unpaired piece. In my specimen this unpaired piece, while very distinct, has not yet developed a hyaline structure. It is in a semi-membranous condition, but

shows no connection with the nasal cartilages except through the connective tissue that in this region binds together premaxilla, vomers and nasal cartilages. Wiedersheim says that in the adult the anterior ends of the vomers come in contact in the middle line just posterior to this isolated unpaired cartilage. In a dry preparation of an adult skull I find a postero-ventrally directed conical bony process of the premaxilla slightly overlapping and wedged in between the anterior ends of the vomers. This is in the position occupied by the isolated cartilage in question in my young specimen and in the adult condition as described by Wiedersheim and Hay. I do not find the bony process in the young specimen.

The vomers (vermero-palatines) require little mention beyond that of the preceding paragraph.

The maxillae and the prefrontals have essentially the adult relations. Along the border of the maxilla are numerous teeth, of which only three are as yet consolidated with the maxilla.

The frontals at this stage do not meet in the middle line, except at the peculiarly modified anterior portion underlying the dorsal process of the premaxilla. The frontal consists of two portions. There is an external part roofing in the anterior brain cavity of its respective side. Posteriorly this portion overlaps the parietal, and antero-laterally rests on the anterior prolongation of the trabecula, known as the tectal cartilage. A second portion of the frontal is, at this stage, a thin sheet extending antero-ventrally from the anterior border of the dorsal part of the bone, mesial to the tectal cartilage as far as the ethmoidal basal plate and nearly to the middle line, forming the chief part of the anterior wall of the brain cavity and closing the greater part of the large opening between the dorsal tectal cartilage and the ventral trabecula. At this stage this part of the frontal is imperfectly ossified and its exact limits are hard to define. At its dorsomedian border is the olfactory opening into the nasal capsule. The peculiar structure of the anterior end of the frontal has been noticed and figured by Wiedersheim, by

Hay, and by Wilder. A process which may be regarded as a prolongation of the dorsal part of the frontal extends antero-ventrally dorsal to the cartilaginous nasal septum so far as to lie at the side of the posterior part of the bony nasal septum (premaxilla). The portion of the process immediately posterior to the bony nasal septum meets in the middle line the corresponding process of the opposite side ventral to the dorsal process of the premaxilla. This, the posterior part of the dorsal process of the frontal, forms the dorsal and median wall of the olfactory opening, the ventral and external wall of the latter is formed by the border of the second part of the frontal above described. In later stages the antero-dorsal process apparently fuses with the ventral sheet near the middle line, thus forming a complete ring of bone around the olfactory opening. At this stage, however, the ring is incomplete on the median side. Hay seems to question the accuracy of the statement of Wiedersheim that in the adult the anterior part of the frontal forms a canal in which lies the olfactory nerve as it passes into the nasal capsule, but a careful examination of an adult skull can hardly fail to confirm Wiedersheim's statement. In my specimen the olfactory opening has not as yet assumed a canal-like form.

The parasphenoid has approximately the relations of the adult condition. Anteriorly, the pointed portion lying between the two vomers has a groove on its ventral surface, and in this groove is the posterior part of the palatine process of the premaxilla. Toward the tip of the parasphenoid the groove breaks completely through the bone so that the latter is forked and ends in two delicate processes, each closely wedged in between the vomer of its respective side, and the palatine process of the premaxilla. The extreme posterior tip of the latter is so coalesced with the parasphenoid that no line of demarcation can be discerned in the sections.

The parietals do not meet in the middle line except near their posterior ends. Laterally each sends a process over the ear capsule nearly to the squamosum. Antero-laterally each *overlaps* the orbito-sphenoid cartilage. Poste-

riorly they slightly overlap the synotic tectum. The muscular crest overlapping the dorsal border of the squamosum of the adult condition is not yet developed.

The squamosum is an elongate plate extending obliquely across the ear capsule. About two-thirds of its length is applied to the ear capsule, the remainder overlaps the quadrate. Beginning at a level somewhat posterior to the posterior border of the operculum (stapes), it extends antero-dorsally, its ventral edge slightly overlapping the operculum, toward the middle line, nearly reaching the lateral border of the parietal above mentioned. After passing the operculum the squamosum turns and passes antero-ventrally to the quadrate, its ventral border in contact with and resting upon the columella and farther anteriorly upon the quadrate.

Underlying the squamosum is a bone figured and described by Hay as the "columellar process of the quadrate." One may be permitted to suggest that Hay is in error. He describes the bone in practically the adult condition, after it has completely coalesced with the ossification of the quadrate. He fails to see that there is an articulation between the columella and the quadrate, and that this bone lies anterior to the articulation, that is, it is not applied to the columella but to the quadrate. The articulation mentioned occurs at the level where a division of the mandibular branch of the facial nerve passes dorsally around the columella-quadrate bar to go to the oral (Kingsbury) line of sense organs. There is no external discontinuity in the bar, but at the point mentioned the hyaline structure is interrupted by a membranous structure so characteristic of articular surfaces. The bone in question appears as a distinct ossification lying in the hollow of the quadrate and covered by the squamosum, except at its extreme anterior end. Its antero-ventral edge rests upon and is closely applied to the quadrate. Anteriorly it reaches nearly to the anterior border of the latter, and projects slightly beyond the squamosum. Posteriorly its pointed extremity reaches nearly to the level of the articulation in the columella-quadrate bar above described.

Anteriorly it is almost completely coalesced with the ossification of the quadrate, but posteriorly is is completely free. In the advanced stage described by Hay the bone has apparently fused with the ossified quadrate along nearly the entire length of the latter. It may be questioned whether the slight ossification of the quadrate at this stage is not derived from this membrane bone, Furthermore, the ossification of the adult quadrate may be derived, possibly, chiefly from the same source. No discussion of the homology of this bone will be attempted here, as this subject will receive the attention of Professor B. F. Kingsbury.

At this stage of development the elongate otic capsules are ossified but little except at their extreme anterior ends. Kingsley has pointed out the fact that in the younger stage described by him the anterior ends of the ear capsules "project slightly beyond the point of union with the cristae trabecularum." In the stage studied by me these projections are of considerable length and completely ossified. Posteriorly they coalesce with the ossified portions of the ear capsules, anteriorly they have every appearance of being membrane bones. But one must have access to earlier stages to definitely determine the origin of these projections.

On the pterygoid bars are small membrane bones.

THE VISCERAL ARCHES.

On the lower jaw are two membrane bones, a dentary and an angulare. I find no trace of an operculare, such as is found in Necturus and some others. Hay has called attention to the peculiar relations of the membrane bone on the ceratohyal bar in individuals of six inches in length, essentially the adult cendition. The thin splint which in early stages lies on the median side of the ceratohyal later comes to lie between two bars of cartilage, of which the mesially lying one is interrupted at one point. Hay's theory is that the mesial bar is formed by growth from the the main bar around the ends of the bone. In my speci-

men this supposed growth is really taking place, and at each end the bone for a short distance is imbedded in cartilage.

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THE SOLAR SURFACE DURING THE PAST TWELVE YEARS—A REVIEW OF SUN-SPOT OBSERVATIONS MADE AT ALTA, IOWA, FROM 1890 TO 1902.

BY DAVID E. HADDEN.

The following paper is a resume of a series of sun-spot observations commenced by the writer in 1890, August 1st, and continued without interruption, except by cloudy weather and other unavoidable causes—such as sickness or absence from the city—until the present time.

Embracing, as it does, the most interesting period of a sun-spot cycle—that of a maximum of solar activity, included between two minima—it is hoped that a study of the results may be of interest and value to students, and a contribution to the literature of solar physics.

The principal instrument used was a 3-inch telescope until 1897, February, after which time a 4-inch telescope,

equatorially mounted, by Brashear, was employed, using a Herschelian diagonal eye-piece with various powers, usually one magnifying about 78. The method of projection of the solar image to a diameter of 8 or 10 inches was sometimes used, and the positions of the spots and faculae determined by means of Thomsen's discs; but generally the relative heliographic positions were noted by means of cross wires in the eye-piece, and afterwards reduced by reference to the usual "tables for physical observations of the sun."

A spectroscope with a 2-inch Rowland diffraction grating of 14,438 lines per inch, was employed in viewing the prominences and examining spot spectra.

Daily observations were taken, usually about noon in the autumn and winter months, and in the morning between 7 and 8 o'clock during the warmer seasons, when better definition was secured than during the hotter portion of the day; the visual observations consisted of noting the number of groups of spots—each disturbance of one or more spots being considered as a group—the total number of individual spots in each group, and the number of groups of faculae. The relative positions of each of these were plotted on paper, and a sketch made of the appearance of each group, with more detailed drawings of the greater disturbances; in addition, the condition of the definition was noted with reference to the visibility of the granulation of the solar surface and lastly the time of the observation was inserted. The daily results thus obtained have been published from time to time in various journals, and for reference a list is appended to this paper.

During the period under review, about 1,750 groups have been observed on the visible disc, the greatest number, 285 being registered in the year 1893, and least number, eighteen, in 1901.

As the purpose of this paper is but a review of the recent solar cycle of sun-spots, a detailed account of the observations is not attempted, reference for these being made to daily results as contributed to journals and societies given in *the list appended*, as before mentioned; hence only the

greater or more important disturbances will be briefly alluded to, in the following descriptions, which are given for each year.

1890, (AUGUST TO DECEMBER).

Some large sun-spots appeared on the disc towards the end of August, which practically marked the beginning of the new cycle of solar activity, and which reached a maximum about three years later; the minimum probably occurred towards the middle of the year 1899, and as is usual in sun-spot periodicity, the interval from a minimum to maximum is much shorter than the decline from maximum to the next following minimum.

Large spots were also present during the months of September, October, November and December, some especially fine spots being present in the third decade of October.

1891.

This year was one of rapid increase in sun-spot activity; there were ten or twelve spotless days in January, a few in February and March, but after that time the disc was not free from spots for a period of about five years.

Several large and fine groups and spots were observed during the year, notably those on February 17-26th, April 21-30th, May 19-25th, June 25-30th, July 10-25th and August 29th to September 10th; this last disturbance was especially interesting, being large and easily visible to the naked eye. Unusual activity was present in the group during its transit, and its ingress on the disc was marked by brilliant auroras which continued for three nights; the return of this disturbed area at the east limb on September 25th was again attended by brilliant auroras for several evenings.

Another large disturbance made the transit from November 15th to 27th, and is of interest as marking the beginning of the giant outburst of 1892, February.

1892.

The year 1892, like that of 1891, was one of great increase and activity in all solar disturbances. It would be almost impossible to give a detailed account of the many groups of interest which appeared during the year in a paper of this kind, without the use of drawings or photographs to illustrate the appearance of the intricate markings in the large groups. Among the numerous outbursts, however, those of February 5–18th, May 23d–31st, June 18–28th, July 3d–15th, July 24th to August 7th, August 13–25th, September 7–18th, and October 29th to November 6th, were especially fine. The great spot of February was probably the largest visible on the sun's disc in many decades, and was the largest ever photographed on the sun; its length exceeded 100,000 miles and the area 2,000,000,000 square miles.

Several beautiful groups were present in June, accompanied by great activity and numerous spots, exceeding 100 on some days. July and August were rich in magnificent groups, some containing enormous umbræ in large and complicated penumbræ of various forms; these remarkable disturbances were accompanied by some incomparably brilliant manifestations of terrestrial electricity in the form of Aurora Borealis. The solar surface during these months was dotted with eight to thirteen large groups of spots daily.

1893.

All solar phenomena continued to increase during this year; the average daily number of groups and spots combined, reached a maximum during the month of August, after which a marked decline set in, with, however, several fluctuations for a couple of years later. August then marked the apex of the sun-spot cycle extending from 1889.6 to 1901.5, the length of the period from minimum to maximum being about 4.1 years, and from maximum to minimum, 7.8 years.

During the year 1893 very many magnificent groups were present on the sun; especial mention of the group of February 5th to 18th in south latitude is noted as being very intricate with numerous nuclei and interlacing penumbra; several fine auroras were also visible during this period.

The next large group made the transit from March 17th to 30th, and developed into a fine train of spots. Two large and active groups were in south latitude from April 27th to May 14th, one containing curiously shaped umbræ and penumbræ, with many luminous "bridges" crossing the umbræ. The other group was still more active and interesting, undergoing continuous changes from day to day—small spots increasing to large nuclear spots, then forming a train, afterwards a stream, finally becoming single spots again. A large quadruple cluster of spots was visible in June, a fine train of large spots in July, and the disc continued to be spotted with many beautiful groups and trains,—unusual displays of the Northern lights were coincident with these. August was especially rich in fine groups, which were easily visible to the naked eye. A remarkable group appeared at the east limb on the 2d, which by the following day had developed unusual activity and increased enormously with auroral manifestations in the evening; two days later the group still consisted of two huge spots with scorpion-like nucleus in one spot, and was a superb object; aurora continued for several evenings. On the 8th fully 100 spots in fourteen groups dotted the sunspot zones and the climax of the sunspot curve was full of groups of tremendous magnitude, with immense areas of penumbræ, enclosing umbræ of all forms—helical, wing-shaped, triangular, and fimbriated, cruciform, pitcher-shaped, tassel-like, eel-shaped, etc.

Many other interesting groups continued till November and December, when large composite groups were present, fully rivaling in extent, the giant disturbance of February, 1892.

1894.

Like the preceding year, the one now under review was also noted for the persistence of large and very interesting sun-spot groups. Every month of the year witnessed some "greater sun-spot disturbance," thus while the crest of the sunspot curve was undoubtedly passed in the late summer of 1893, the decline was marked at first and then became more gradual with a slight revival until midsummer of 1894, after which time a more pronounced and steady decline set in, until the minimum epoch.

In January a large group visible to the naked eye was present. During February a spot 48,000 miles in length was an interesting object; its umbra, on the 19th, when examined by means of the spectroscope, was the location of brilliant reversals of the Ha line, and when the slit of the instrument was widely opened the reversal presented a flame or tree-like appearance. On the 25th bright reversals took place in the penumbra of the same spot.

Large double spots, with variously formed nuclei were transiting the disc during the first week in April; and in May and June splendid groups of wonderfully complicated and intricate markings were of fascinating interest.

On June 7th a remarkable eruptive prominence was observed with the spectroscope, consisting of "spikes" and "flames," which was in violent commotion; its height was estimated to be 70,000 miles; ten minutes later the entire disturbance had nearly subsided, the shifting of the Ha line towards the blue end of the spectrum indicated a rapid approach in a direction towards the earth; later the region of the photosphere further in, on the disc was violently agitated, the Ha line appeared with blow-pipe looking jets directed towards the red end of the spectrum. Single and composite groups of great size and beauty were noted in August, September, October and December, with much spectroscopic disturbance and strong reversals of Hydrogen lines in the large group of October 6th.

1895.

The steady decline in numbers of solar groups and spots mentioned as having set in during the latter half of 1894, continued during this year, but with some rather sharp fluctuations. During the year several striking disturbances were noted. A train of spots in the southern hemisphere, on January 28th, was the location of considerable spectroscopic disturbance, the Ha line being reversed and distorted in numerous portions of the group. March was noted for a fine group which made the transit from 16th to 26th, about 10° south of the equator.

Some large spots were present during April, a fine normal one on the 28th, near the west limb, contained a dense black hole or nucleus in the umbra. Some beautful and active disturbances were witnessed in the month of June; on the 6th an active protuberance was seen near the new group on the east limb, and the region surrounding the spots near by was spectroscopically active.

On the 16th, much disturbance in and around a large group in north latitude, consisting of reversals and distortions of the Hydrogen lines directed towards the red end of the spectrum, was observed.

Several large spots were observed during the first half of August, one large spot persisting during four solar rotations; its umbra was quite interesting from day to day, at times being single, double, round, irregular and curved.

Other large groups were seen during the closing days of September, the fore part of October, and again during the third decade of the same month; also from November 1st to 9th and latter part of December.

1896.

Notwithstanding the fact that the present year is the third following the maximum, the solar surface contained some unusually large groups during the year. It is worthy of note that the descending curve of solar activity is frequently marked by sudden and enormous outbursts of the solar gases or other forms of energy which give rise to the

formation and appearance of a sunspot. One cannot study the solar surface markings day after day for years, without coming to the conclusion that the mechanism of a sunspot is analogous to our terrestrial cyclones and other storms, the stupendous forces far below the visible photosphere manifesting the violence of their eruptions by the extent, area, color and form of umbra and penumbra, and various other phenomena, including that of terrestrial magnetic and atmospherical electrical effects.

The decline in total number of groups and spots was quite marked during the year under review; several days without spots were noted in April, August and October.

A fine group consisting of from three to five centers of activity was observed from 18th to 29th of February, in north latitude.

An interesting feature of May was the development from a few dots to a group of considerable size on the visible disc from the 26th to 3d of June.

A great spot which underwent many changes passed across the disc from July 12th to 24th; on the 20th its area was nearly 400,000,000 square miles. September brought the most remarkable group of the year—a stream of spots extending over 26° of solar longitude, or about 190,000 miles—first observed as irregular spots near the east limb, on the 10th, and rapidly increased by the next day with many nuclei; the groups increased daily until the 20th, when the greatest elongation occurred; by the 22d it was passing out of view round the west limb, and must have rapidly declined on the invisible disc of the sun, as its return during the following month was marked by only a normal spot.

A brilliant solar protuberance was witnessed on October 23d, at the east limb, position angle 110°, almost directly over a large spot which was coming into view; it was in violent agitation, but was of short duration, as the disturbance entirely subsided in about an hour. My detailed account of the phenomenon was published in *Popular Astronomy* for December, 1896. Two days later a large

feather-like prominence was on the west limb; its height was fully 90,000 miles.

1897.

Like the preceding year, the one now being reviewed was remarkable for several highly interesting groups, especially those of January, May, August, September and December, which appearing about midway between the maximum and minimum of the sun-spot curve, furnished new material for speculation as to the nature of sun-spot phenomna. The gradual decline in the total number of groups and spots continued during the present year, with a decided increase in the number of spotless days. The year began with a magnificent group on the disc, from January 3d to 15th, which reached a length of about 120,000 miles, and a breadth of about 47,000 miles, and enclosing a area of nearly 2,800,000,000 square miles; this enormous group was in a very active state during its entire appearance, and its umbra was noted as having various tints of color from 7th to 11th, being reddish-brown, shading into gray and green, and finally a uniform black. A considerable group was present early in May, and another one during the closing days of the same month.

No spots were visible during several days of May and June--forerunners of the minimum yet three years away. During August a fine spot, the largest since January, made the entire transit across the disc. On September 2d a group of small spots appeared at the east limb by solar rotation, in south latitute 12°-15° which, by the following day, became very active with spots increasing, and the hydrogen lines in their spectra reversed and distorted in numerous portions of the group, activity continued every day thereafter until its disappearance, with constantly changing umbra and outlines; strong cyclonic motion was apparent in the penumbra and projecting umbral filaments on the 6th, the motion being counter-clockwise; during the following day the group was breaking up, with shattered umbra, crossed by "bridges." The year closed with

a large group of much activity, which passed over to the invisible side of the sun on December 19th.

1898.

During the present year fully two-thirds of all the sun-spots observed were small; the number of spotless days slightly increased, and the average number of groups and spots remained fairly steady compared with the preceding year.

The year under review was also remarkable for the appearance of several fine outburts which occurred in the months of February, March, September, October and November. The group of February 9th to 20th was at first but a few small spots at the east limb, but which in a few days rapidly increased, becoming a very fine train, fully 130,000 miles in length, on the 14th, but much diminished before reaching the west limb.

Another considerable stream appeared from March 5th to 17th, with dimensions fully as large as the February group, and showing much activity on the 10th.

By far the greatest and finest group of the year appeared in the month of September, from 2d to 15th; this group probably originated about August 11th, as a cluster of tiny spots, and finally disappeared on November 7th, hence completing four rotations to the central meridian. Appearing at a period of fast approaching minimum, this group was remarkable for its enormous size and associated spectroscopic and magnetic and electrical manifestations. The following account of it is transcribed from my observing note book: "When I first observed it, but a mere line of light separated it from the edge of the east limb, no penumbra being visible, except on the north and south edges of the long umbral line; a bright aurora was coincident with its ingress the same evening. On the following day penumbra was visible on all sides of the umbra and the spot promised to be interesting, the changes from day to day being quite marked. Owing to unsatisfactory atmospheric conditions, the spectroscope could not be used until the 6th, when *but little* or no disturbance could be noticed in the

vicinity of the spot. On the 7th, however, a sudden outburst occurred: when the spectroscope was adjusted at 11:40 A. M., the entire region just preceding and for some distance following, and also north and south of the spot was greatly agitated, the Ha line being reversed and distorted. small dark jets projecting from either side of the line were noted in several places, and upon opening the slit slightly, the flame and spike-like form of the disturbance could be clearly seen, extending from the umbra to the edge of the penumbra on the east edge; this phenomenon was particularly striking--the intensely bright scarlet flame nearly in the center of the dark absorption band of the spot spectrum being very interesting, the D3 line of Helium was bright, and D1 and D2 and numerous other lines widened. At 12:05 P. M. a small dark line, attached to the Ha line, extended obliquely towards the red end of the spectrum in the region just preceding the chief spot.

Observations were interrupted at 12:10 P. M. and could not be resumed again until 1:40 P. M., but the entire disturbance had then almost ceased, only a few slight reversals being noted."

The maximum length of the group was about 140,000 miles and the dimensions of the chief spct about 50,000 miles in diameter. This group returned by solar rotation again in the closing days of September, and disappeared after its third rotation at the west limb on October 12th, surrounded by extensive and brilliant faculæ.

1899.

All solar phenomena declined rapidly during this year, the average number of groups, spots and faculæ being over 50 per cent less than in the preceding year. The total number of days without spots amounted to 108 out of a possible 259 days of observation, or nearly 42 per cent, compared with 13 per cent for the year 1898.

Spotless days occurred every month of the year, the number being greatest in the month of August. The

northern hemisphere of the sun was the least disturbed, being nearly one-fourth less than the southern.

While the sun was now rapidly approaching the period of solar activity when the spots are smaller, fewer and more transitory; still a few interesting groups were observed this year. On March 15th and 26th fairly large spots entered the disc and made the transit; the latter one was unique in that the major axis of its umbra seemed to have a cyclonic motion, which nearly completed a revolution around its common center.

The next important spot, and, in fact, the largest of the year, entered at the east limb on June 23d—an oval spot, with "bridged" umbra and much spectroscopic activity on the 26th; the spot was increasing on the 27th, its umbra being a deep purple color, and having near its center an intensely black "hole" or nucleus; it still increased with branching umbra and penumbra, and later was breaking up, not to reappear at a subsequent rotation. A somewhat large normal spot passed across the disc during the first half of July, after which date a period of prolonged quiescence set in, lasting during the rest of the year, with occasional small transitory spots in September and October.

1900.

The average number of groups, spots and faculæ continued to diminish during the present year, and the total number of spotless days increased to 134 or 52½ per cent of the number of days of observation.

Periods of absolute tranquility occurred in every month of the year.

The principal spots observed were in March, April, May and October. The March group appeared suddenly, and during several rotations the region was active; the disturbance finally disappeared during the first week in May. The telescope was dismounted and shipped to Wadesboro, North Carolina, shortly after May 16th, where the writer successively observed the total eclipse of the sun on May 28th. Observations were not again resumed regularly until June 3d. *Mainly small* and sporadic spots were noted during

the balance of the year, except a large-sized group which later formed a stream of small spots in October. The closing two months of 1900 were absolutely quiet.

1901.

The year now under review marks the end of the eleven year cycle of solar activity, the minimum having in all probability been reached by the middle of the year.

In August some few short-lived spots broke out in high southern latitude, which would indicate that the new cycle had commenced, as it is now fully demonstrated that spots of a new curve of activity first appear in high latitudes and gradually approach the equator as the period progresses, until as the minimum is reached again, the evidences of the dying cycle are found in zones within the equatorial regions.

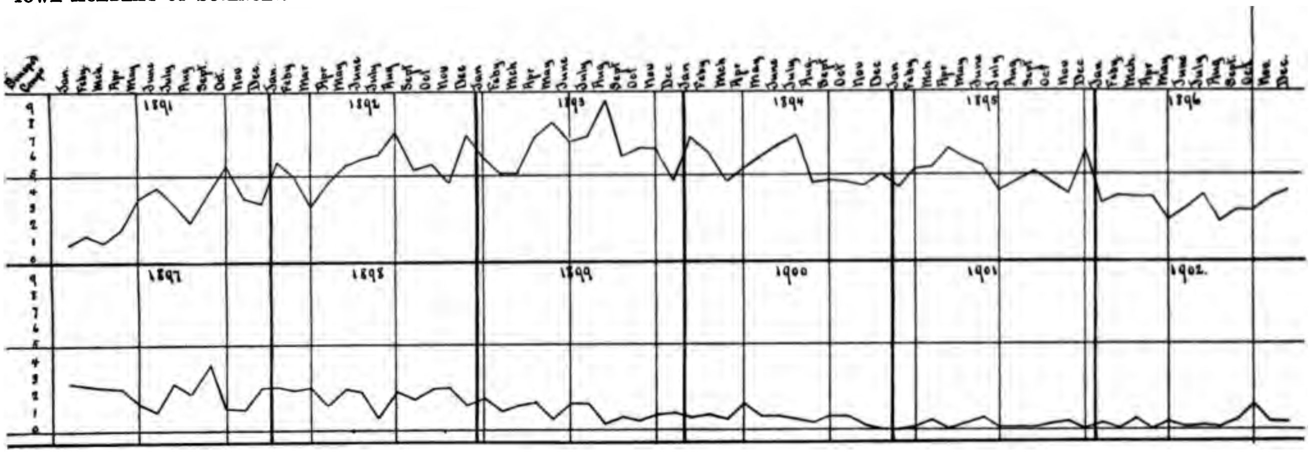
During the year 1901 there were 212 spotless days out of a total of 269 days of observation, or nearly seventy-nine per cent.

The most noticeable characteristic of the year's record was the sudden outburst of a large spot in May, which was easily visible to the naked eye; its low latitude indicated that it belonged to the expiring cycle rather than to the incoming period. Coming at a period of absolute quiescence, it was certainly a surprise to observers of solar phenomena. It was the final outburst of the pent-up forces which brought the minimum to an end.

1902.

During the first half of January an average sized group crossed the visible disc near the equator; this was followed by a period of perfect quiescence—an entire absence of spots and faculae—lasting until March 1st, when a fairly large group in high north latitude, belonging to the new cycle, completed the transit. Another period of prolonged tranquility followed, which lasted until May 23d, on which date a normal spot appeared, which in all probability was a return of the March group, but which was not visible in

Plate XXIII.



the interum rotations; but in its place, on March 30th, a bright faculae at the east limb was coincident with an unusual manifestation of the aurora—a full account of which I contributed to *Popular Astronomy* for May, 1902, extracts of which are given here. "About 9 o'clock in the evening of March 29th, 1902, a bright auroral beam was observed in the south-east sky, at an altitude of about 30 degrees. When first seen it was more or less obscured by light clouds, and its true nature was hard to determine. It was a perpendicular, pale, narrow streak of light, about 5 degrees in length and about ½ degree in width, with the star Gamma in the constellation Virgo, about exactly in the middle of the beam. About twenty minutes later the clouds cleared away and the beam was a beautiful object, resembling strongly a fine comet of a pale greenish white light. Ten minutes later it reached its maximum brightness, when it was a deep yellow to orange color, and had moved about a degree farther north. Underneath, towards the horizon, was a dark region, above which was a faint auroral glow. Five minutes later the phenomenon disappeared, and did not appear again. Its position in the south-east sky was unusual."

After the disappearance of the May group, the sun's surface was practically spotless for a period extending over four rotations.

During the latter part of September and in October, fair sized groups in south latitude, belonging to the new cycle, were present.

No disturbance of the first magnitude was visible during the year. There were 163 spotless days out of 230 days of observation, or about seventy-one per cent, which indicates the uncertainty and sometimes difficulty of determining the precise date of the minimum epoch.

In the following tables are given the numerical summaries of all the observations from August, 1890, to December, 1902, inclusive. The columns are self-explanatory.

The results thus tabulated are shown graphically in Plate XXIII, which exhibits the progress of the average daily numbers of spot groups.

MONTHS.	NUMBER OF OBSERVING DAYS.	AVERAGE NUMBER OF—			AVERAGE NUMBER OF GROUPS IN—		Number of spotless days.
		Groups.	Spots.	Faculæ.	North latitude.	South latitude.	
1890—August	27	0.6	2.5	......	......	......	13
September	26	1.0	2 6	......	......	......	5
October	19	0 8	4.0	......	......	.....	7
November	25	1.2	3.7	......	......	......	11
December	24	0.8	2.4	......	......	......	13
1891—January	25	1.0	2.7	1.7	......	......	13
February	20	1.6	7.3	1.3	......	....	6
March	21	1.1	2.5	2.2	.....	......	3
April	23	1.9	12.2	3.1	.....	......	0
May	28	3.6	16.8	4.1	......	......	0
June	17	4 2	16.9	5.3	......	......	0
July	24	3.5	26.1	5.7	......	......	0
August	18	2.2	13.0	4.4	......	....	2
September	23	4.0	23.1	5.2	......	.....	0
October	23	4.6	19.5	3.6	......	....	0
November	17	3.8	23.1	3.6	......	......	0
December	18	3.4	15.6	3.1	......	.....	0
1892—January	24	5.8	28.0	4.1	......	......	0
February	13	5.0	46.0	3.5	......	......	0
March	14	3.2	14.0	3.1	......	......	0
April	13	4.6	21.5	4.6	......	.....	0
May	5	5.6	30 0	2.6	......	......	0
June	23	6.0	35.0	4 4	......	......	0
July	22	6.2	56.9	4.4	......	......	0
August	23	7.6	38.4	5.1	......	......	0
September	18	5.3	30.2	5.7	......	......	0
October	22	5.7	41.6	4.6	.....	......	0
November	15	4.7	35.4	3.2	.....	......	0
December	13	7.4	31.1	4 0	.....	......	0
1893—January	13	6.1	42.3	3.5	......	......	0
February	15	5.1	42.4	3.4	. ..	......	0
March	17	5.1	30.0	3.3	......	......	0
April	15	7.3	31.5	3.9	.....	......	0
May	19	8.1	31.5	4.5	.....	......	0
June	8	7.0	46 7	4.6	......	......	0
July	22	7.4	49.3	4.4	......	......	0
August	21	9.4	53.8	4.7	......	......	0
September	24	6.1	34.6	4.4	......	......	0
October	10	6.7	30 7	4.7	....	......	0
November	7	6.6	24.7	4.0	......	......	0
December	6	4.8	21.7	3.0	......	......	0
1894—January	9	7.2	40 0	3.7	....	......	0
February	19	6.4	26.6	2.9	......	....	0
March	8	4.6	21.0	3.8	......	......	0
April	7	5.3	25.4	3.7	......	......	0
May	13	6.1	33.5	3.0	......	......	0
June	20	6.8	30.3	3.4	......	......	0
July	20	7.3	34.6	3.8	......	.....	0
August	13	4.5	22.1	3.2	......	.....	0
September	10	4.7	17.5	3.3	......	......	0

MONTHS.	NUMBER OF OBSERVING DAYS.	AVERAGE NUMBER OF— Groups.	Spots.	Faculæ.	AVERAGE NUMBER OF GROUPS IN— North latitude.	South latitude.	Number of spotless days.
1894—October	12	4.6	34.5	3.6	.....	......	0
November	7	4.4	16.6	2.8	.....	......	0
December	1	5.0	28.0	4.0	......	.....	0
1895—January	6	4.2	....	4.2	......	......	0
February	11	5.3	23.6	3.5	.....	......	0
March	13	5.4	25.7	4.0	......	......	0
April	5	6.6	32.8	4.8	......	......	0
May	7	6.0	34.9	4.1	......	......	0
June	10	5.6	43.1	3.6	......	......	0
	30 [B. A. A.]	B A A.					
July	*	4.0	......	.....	......	......	0
August	22	4.7	43.9	2.9	......	......	0
September	19	5.1	22.3	2.8	.....	......	0
October	20	4.6	35.5	3.3	......	......	0
November	16	3.9	16.2	2.9	......	......	0
December	17	6.3	27.1	2.9	......	......	0
1896—January	9	3.2	8.5	3.2	1.1	2.1	0
February	18	3.8	24.0	2.5	2.1	1.7	0
March	16	3.7	14.8	2.6	1.1	2.6	0
April	17	3.7	21.8	3.2	2.0	1.8	2
May	18	2.3	10.7	2.6	0.6	1.7	0
June	16	3.0	23.1	2.3	0.9	2.1	0
July	23	3.8	15.1	2.7	0.9	2.8	0
August	20	2.2	10.7	2.6	0.4	1.8	2
September	17	2.9	31.2	3.3	1.0	1.9	0
October	21	2.9	12.9	2.6	1.0	1.8	1
November	12	3.6	16.0	3.2	0.7	2.8	0
December	10	4.0	24.7	3.6	1.5	2.5	0
1897—January	10	2.9	28.7	3.4	0.2	2.7	0
	19 [B. A. A.]						
February	3*	2.7	.....	......	1.3	1.4	0
March	14	2.6	9.9	2.5	2.4	0.2	0
April	6	2.5	7.5	2.7	2.3	0.2	1
May	22	1.6	7.7	2.3	0.6	1.0	6
June	20	1.1	4.8	1.4	0.1	1.0	7
July	26	2.8	11.3	1.8	0.5	2.3	0
August	28	2.1	9.5	2.3	0.3	1.7	0
September	28	3.8	22.2	2.8	2.0	1.8	0
October	14	1.3	3.3	2.3	1.0	0.3	5
November	16	1.2	3.8	1.3	0.4	0.8	5
December	11	2.5	12.6	2.4	1.9	0.6	0
1898—January	18	2.6	9.3	2.7	2.0	0.7	1
February	20	2.4	16.5	2.0	1.0	1.4	2
March	23	2.6	15.0	2.4	0.6	2.0	6
April	25	1.5	6.7	2.2	0.3	1.2	3
May	18	2.4	13.3	2.8	0.3	2.1	0
June	24	2.2	9.5	2.5	1.1	1.2	2

*NOTE—Owing to absence from town during the greater portion of July, 1896, and July, 1898, and insufficiency of observations in February, 1897, and July, 1898, a part of the data given is supplied from the British Astronomical Association solar section reports.

MONTHS.	NUMBER OF OBSERVING DAYS.	AVERAGE NUMBER OF—			AVERAGE NUMBER OF GROUPS IN—		Number of spotless days.
		Groups.	Spots.	Faculæ.	North latitude.	South latitude.	
1898—	30 [B. A. A.]*	0 7					
July..........	9	0.4	0.9	2.8	0.1	0.6	6
August.......	24	2.2	13.9	2.2	1.0	1.2	2
September....	25	1.9	11.6	2.3	0.7	1.2	1
October	16	2 4	15 0	2.3	1.2	1.2	0
November.....	16	2.5	15.0	2.3	1.0	1.5	0
December.....	16	1.5	5.0	2.2	0.4	1.0	2
1899–January.......	22	1.9	10 0	1.9	0.2	1.7	1
February......	18	1.1	4.8	1.8	0.0	1.1	6
March	17	1 5	5.5	1.4	0 3	1.2	2
April	22	1.7	3 2	1.5	0.3	1.5	1
May	24	0.7	2.6	1.0	0.0	0.7	7
June..........	25	1.6	10.0	1.6	0.7	0.9	2
July..........	29	1.5	6.7	2.0	0.4	1.1	8
August........	27	0.3	0.6	1.8	0.2	0.1	21
September....	27	0.8	3.4	1.4	0.1	0.7	13
Octob r	22	0.5	4.3	1.4	0.1	0.4	15
November	18	0.9	3.3	0.9	0 3	0.6	7
December.....	9	1.0	2.8	1.2	0.4	0.6	3
1900—January.......	21	0.7	2.5	1.2	0.4	0.3	9
February.....	13	0.9	5.2	0.7	0.6	0.3	7
March........	23	0.6	2.0	1.0	0 2	0 4	12
April	21	1.5	7.0	1.7	0.7	0.7	1
May	15	0.8	5.7	1.3	0.4	0.4	8
June..........	27	0 8	4.5	0.9	0.4	0.4	13
July..........	27	0.6	2.6	1.1	0 2	0.4	16
August........	28	0.4	1.6	0.6	0.0	0.4	20
September	24	0 8	3.1	0.8	0.0	0.8	13
October	23	0.8	6 0	1.0	0.0	0.8	7
November.....	17	0.3	0 6	0.6	0.0	0.3	12
December.....	16	0 0	0.0	0.8	0 0	0.0	16
1901—January......	20	0.0	0.0	0.2	0.0	0.0	20
February......	20	0 15	0.15	0.4	0.15	0.0	17
March.........	17	0.6	2.1	0 4	0.5	0.1	11
April	23	0.0	0.0	0 3	0.0	0.0	23
May	26	0.4	3.7	0.5	0.4	0.0	16
June...........	24	0.8	2.1	0 6	0 6	0.2	11
July	30	0.1	0 1	0.4	0.00	0.10	27
August........	28	0.1	0.2	0.2	0.07	0.03	25
September.....	25	0.1	0.1	0.0	0.04	0.04	23
October	24	0.3	1.0	0.4	0.04	0.26	18
November.....	22	0.5	0.8	0.4	0.00	0.50	11
December.....	10	0.0	0.0	0.0	0.00	0.00	10
1902—January.......	23	0.4	2.0	0.2	0.00	0.39	14
February......	19	0.0	0.0	0.0	0.00	0.00	19
March	18	0.7	5.9	0.4	0.61	0.06	9
April	20	0.0	0 0	0.3	0.00	0 00	20

*NOTE. Owing to absence from town during the greater portion of July, 1896, and July, 1898, and insufficiency of observations in February, 1897, and July, 1898, a part of the data given is supplied from the British Astronomical Association solar section reports.

MONTHS.	NUMBER OF OBSERVING DAYS.	AVERAGE NUMBER OF—			AVERAGE NUMBER OF GROUPS IN—		Number of spotless days.
		Groups.	Spots.	Faculæ.	North latitude.	South latitude.	
1902—May	20	0.4	0.8	0.4	0.40	0.00	12
June	20	0.1	0.3	0.3	0.15	0.00	17
July	24	0.2	0.3	0.5	0.17	0.00	20
August	24	0.1	0 2	0.2	0.12	0.00	21
September	22	0.5	2.6	0.6	0.27	0 27	14
October	17	1.3	7 6	0.7	0.30	1.00	2
November	13	0.4	3.5	1.1	0.38	0.08	8
December	10	0.3	0.9	1 4	0.30	0.00	7

The following tables exhibit the greatest and least number of sun-spot groups visible on any day during each month of the twelve years record:

MAXIMUM DAILY NUMBER OF SUN-SPOT GROUPS.

MONTHS.	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
January		4	11	11	10	7	6	5	6	3	2	0	1
February		3	8	9	8	9	6	5	4	3	3	1	0
March		2	6	10	8	8	5	5	6	3	2	2	2
April		4	7	10	7	8	7	7	4	3	4	0	0
May		5	7	11	9	10	4	4	4	1	2	1	1
June		7	9	11	9	7	5	3	5	3	2	2	1
July		8	13	10	11	8	9	5	3	4	2	1	1
August	2	5	10	14	8	8	5	4	4	3	2	1	1
September	2	8	9	9	9	9	6	6	4	3	2	1	3
October	2	5	8	12	7	8	6	5	4	2	2	2	2
November	4	8	9	9	6	6	6	3	5	2	1	1	2
December	3	7	13	9	8	11	8	5	3	2	0	0	1

MINIMUM DAILY NUMBER OF SUN-SPOT GROUPS.

January	....	0	2	2	4	3	1	1	0	0	0	0	0
February	...	0	1	2	4	3	1	1	0	0	0	0	0
March	....	0	1	3	3	4	1	1	0	0	0	0	0
April	....	1	2	4	3	5	0	0	0	0	0	0	0
May	....	2	4	6	3	1	1	0	1	0	0	0	0
June	....	1	4	5	5	4	2	0	0	0	0	0	0
July	....	2	3	4	4	1	1	1	0	0	0	0	0
August	0	0	4	6	2	2	0	1	0	0	0	0	0
September	0	1	3	4	2	2	1	1	0	0	0	0	0
October	0	3	2	5	2	2	0	0	1	0	0	0	0
November	0	2	3	4	3	1	2	0	1	0	0	0	0
December	0	1	2	2	2	1	2	1	0	0	0	0	0

In the subjoined table is given the average annual results for each year from 1891 to 1902.

YEARS	NUMBER OF OBSERVING DAYS.	AVERAGE ANNUAL NUMBER OF			TOTAL NUMBER OF SPOTLESS DAYS.	PER CENT OF SPOTLESS DAYS.
		GROUPS.	SPOTS.	FACULAE		
1891...	257	2.9	14.9	3.6	24	9 3
1892...	205	5.6	34.0	4.1	0	0.0
1893...	177	6.6	36.6	4.1	0	0.0
1894...	139	5 6	30.0	3.4	0	0.0
1895...	149	5.2	30.5	3.5	0	0.0
1896 ..	197	3 2	17.8	2.9	5	2.5
1897...	198	2.2	11 0	2 3	29	14.6
1898...	234	2.1	11.0	2 4	30	12.8
1899...	259	1.1	4.8	1.5	108	41.7
1900...	255	0.7	3 4	1.0	134	52.5
1901...	269	0.25	0.9	0.3	212	78.8
1902*..	220	0 38	2.1	0.4	156	71 0

*Not including month of December.

Plate XXIV represents graphically the summaries of the groups and spots, the former being indicated by the heavy, smooth line, and the latter by the dotted one.

In conclusion the author would state that the foregoing brief and rather unsatisfactory review of the recent sun-spot cycle was written rather hurriedly, but he trusts that the account, as given, may not be uninteresting.

All the observations were faithfully and accurately made, and represent the conscientious labors of one who has been occupied in an active business career and pursuing other astronomical and meteorological studies as a recreation. He is not unmindful of the many shortcomings, and the difficulties involved in a discussion of the results.

List of the author's published sun-spot observations:

1890. September to December.—Mon. Rev. I. W. and C. S.
1891. January to December.—Mon. Rev. I. W. and C. S.
1892. January to December.—Mon. Rev. I. W. and C. S.
1893. January to May.—Mon. Rev. I. W, and C. S.
1894. May to December.—Mon. Rev. I. W. and C. S.
1895. January to June, A ust to December.—Mon. Rev. I. W. and C. S.
1895. Review Solar Observations, 1891 to 1895, (June).—Pub. A. S. P., Volume 8, No. 45.
1896. January to December.—Mon. Rev. I. W. and C. S,
1896. Review Solar Observations, 1895, (August to December), and 1896.—Pub. A. S. P., Volume 9, No. 55.
1898. Large Sun-spot of September.—P, A., Volume 6, No. 8.
1899. Review Solar Observations, January to August.—P. A., Volume 7, No, 8.
1899. Review Solar Observations, September to December, P. A., Volume 8, No. 4.


Spots.
Groups.
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902.
35
30
25
20
15
10
5
0
8
7
6
5
4
3
2
1
0
Spots.
Groups

1900. Review Solar Observations.—P. A., Volume 10, No. 5.
1901. Review Solar Observations.—P. A., Volume 10, No. 7.
1896 to 1902. Daily record contributed to Solar Section British Astronomical Association, and results published in B. A. A. Memoirs.
Abbreviations.—Mon. Rev. I. W. and C. S., Monthly Review of the Iowa Weather and Crop Service, Des Moines. Pub. A. S. P., Publications of the Astronomical Society of the Pacific, San Francisco, Cal. P. A., Popular Astronomy, Northfield, Minn.

THE DUCK HAWK—(FALCO PEREGRINUS ANATUM)—IN IOWA.

BY B. H. BAILEY.

Few birds of the United States are more widely and generally distributed, and probably no one species is more isolated as to the individual pairs than the Duck Hawk, (Falco peregrinus anatum).

The Duck Hawk, Great Footed Hawk, Peregrine Falcon, etc., as he is variously called, is a "Noble Falcon," one of the really blue blooded Falconidae. Some years ago I met this species in Linn county, and the pair with which I became acquainted having been observed before and since by my friend, Mr. Geo. Burge, of Mt. Vernon, I have obtained largely from him the following facts concerning these birds. In the south-eartern part of Linn county, and extending to the north-eastern part of Johnson county, the Cedar river has cut its channel through the limestone hills of this region, and has left on either side cliffs known locally as the Palisades, raging from a few feet to nearly 100 feet in height.

On the face of these rocks grow lichens of various hues, and bushes interspersed with stunted cedar trees. In many places weathering has produced fissures and crannies which have been for years the resort of the Turkey Buzzards (Cathartes aura) and an occasional Gt. Horned Owl (Bubo virginianus). Here in 1892 Mr. Burge first noted the presence of the Duck Hawk.

The first year two pairs were seen and eggs were collected from each pair, but after 1892 only one pair returned. Before considering the nesting habits, some observations as to migration, hunting, feeding, etc., may be of interest.

The birds arrived from the south regularly in the first half of March, the 10th of this month being their earliest appearance, and staid until the latter part of September or first of October. Both birds appeared and left at the same time in the spring and fall. Their coming corresponds very nearly with the arrival of the early flights of water fowl. The hunting habits of these birds is of interest. The male bird seemed to play by far the largest part in the hunting excursions, while the female attended more strictly to household duties, remaining in the vicinity of, if not on the nest. Starting from the nest in the cliff of the Upper Palisades about 7 A. M., the male bird would fly across and up the river to the bottom lands some distance away. The flight is accomplished by short and rapid strokes of the wings, except when striking the quarry, and occasionally when sailing slowly around near the nest, which is infrequently done. Between 9 and 11 o'clock he returned and alighted in a tall oak snag almost directly across the river from the nest, calling his mate with a sounds like kak, kak, kak, repeated rapidly, starting rather low and uttered with increasing volume, the two would discuss the results of the hunt.

The early morning seemed to be the favorite time of day for hunting, and they were never seen to hunt in the vicinity of the nest. After the morning meal was eaten the birds were inclined to be rather noisy about the nest till noon, from which time till about 4 P. M., they spent the time quietly resting. The weather affected the hunt very little as the same program was carried out on rainy as well as bright days. They were never seen hunting together, and the same hunting ground was resorted to day after day.

The female was easily recognized by her greater size and her boldness when the nest was approached. At such times she would come within three feet of the intruder,

and if there were young in the nest both birds seemed furious and were very bold. On one occasion the bird was seen to take a lone Teal duck, which was following some distance behind a flock of its kind. The Falcon started in pursuit, and the little Blue winged Teal, realizing its danger, redoubled its speed and began to squawk its alarm in unmistakable notes, the Falcon flying parallel to and about a rod distant from its course of flight, with rapid beats of its wings, speedily gained a point opposite the duck and then, with astonishing swiftness, struck the Teal almost at right angles. The blow was delivered with such precision and such stunning force that the feather flew in all directions.

Mr. Burge remarked that "If the Falcon had struck the duck twice, he would certainly have had him picked." The Teal fell into the water some distance from shore, and was carried thence to their favorite snag, where the two proceeded to tear it to pieces.

The first set of eggs secured by Mr. Burge at the lower Palisades, on the 25th of April, 1892, contained four eggs varying from 2-2.96 inches to 1-98.96 inches in length, and from 1-58.96 inches to 1-64.96 inches in breadth. In color, two were uniformly spotted over the entire surface, with reddish brown on a creamy buff background; the third showed almost no background whatever, and the fourth is washed around the small end with dark lilac and coffee color.

The nest was inaccessible without a rope. Incubation was well advanced. Another set had been taken from a a nest near by four days previous, on April 20th. They were also badly incubated and were destroyed, as the man who secured them did not know their value nor how to preserve them. The same man secured a second set from the nest where Mr. Burge took his first set of four, about three weeks after the laying of the first set. They were also destroyed.

In 1893 Mr. Russel Moore took a set of eggs from the highest cliff in the upper Palisades. This set was taken April 5th. The set varied in length from two inches to

1-89.96 inches, and in breadth from 1-59.96 inches to 1-63.96 inches. One egg was very heavily colored, one very lightly spotted and one was marked most heavily at the small end. The eggs were fresh, four in number, and were placed in a hole which extended four feet into the face of the cliff and was sixty feet above the water. This seemed to be their favorite nesting place, although, when persistently molested they would desert it for two other places, as will later be noted.

In no case was there to be found any nesting material carried by the birds to the nesting site. Occasionally the feather of a Flicker (Colaptes auratus) or Kingfisher (Ceryle alcyon) would be found, but the eggs were always laid on the powdered rock or pebbles in the back part of the hole.

In the same year, (1893), on May 2d, I collected a second set of three eggs in the same cliff, but placed in a niche about thirty feet above the water, and accessible by climbing from a boat below. This nesting site was used two years later by a pair of Gt. Horned Owls.

In 1894 the Duck Hawks nested in their favorite place and continued to nest there till 1897. The first set in 1894 contained four fresh eggs, April 12th, which varied in length from 1-89.96 to two inches, in breadth from 1-59.96 to 1-61.96. In this set one egg was very heavily marked, and in one the blotches were confluent about the smaller end. The other two are not peculiar.

A second set of three eggs was allowed to hatch. The birds laid almost immediately after the first set was taken and the young were about near the last of May or first of June.

On April 12, 1895, a set of five eggs was collected, which vary in color only with regard to the amount of light background showing through the deep reddish brown spots and washes. In size they vary from 1-86.96 to two in length by 1-58.96 to 1-66.96 in breadth.

About two weeks later a second set of three was taken, one of which was almost without markings, another very heavily marked with red, while the third was scarcely

three-fourths the size of a common egg of this species. This set I did not have the pleasure of seeing.

On April 8, 1896, a set of six fresh eggs was taken at the Upper Palisades. This set is peculiarly marked, having pronounced washes of reddish coffee color often at the small end of the eggs and showing a peculiar purplish lilac as a deeper ground color. One or two eggs are irregularly daubed with black at the smaller end. They vary in length from 1-78.96 to 1-94.96 inches, and in breadth from 1-47.96 to 1-56.95 inches. A second set of three eggs hatched some distance below and on the opposite side of the river from the usual nesting site. The young birds were all killed before reaching maturity.

Up to this time it had been easy to start the birds from the nest by clapping the hands or striking an oar upon the water, but now the birds having become wiser, it was only when the nest was approached very near that the old birds could be flushed.

On the 1st of May, 1897, a set of four fresh eggs was taken from the site where in 1896 the three young birds were seen. The birds seemed for some time to be considering the old site at the upper cliff, but finally decided on the lower cliff, and hence the late date of this set. There is a possibility of this being a second set, but as the birds were closely watched it is quite unlikely. One of these eggs appears as though it had been steeped in strong coffee. It is also quite pointed. Another appears as though but half immersed in the same fluid, and the others are not specially peculiar but lighter in color. They vary in length from 1-84.96 to 1-59.96 inches, and in breadth from 1-53.96 to 1-59.96 inches. No second set was taken during this year.

In 1898 the last set was taken from this pair of birds. They had returned to the old nesting site in the upper cliff and there deposited a set of six eggs, which were fresh when taken, April 6th. This set is peculiar in its contrasting colors. The background being in sharp contrast with the dark reddish splashes of color in three cases, centered at the large end and in two instances at the small end of

the egg; the sixth egg showing the lilac shell markings noticed in only a few of the eggs.

A second set was laid and three young were hatched, but were killed before reaching maturity. Shortly after this one of the old birds was shot. The remaining falcon staid until June, when it disappeared, and none of this species have since been seen in the vicinity of the Palisades.

In considering this series of observations carried on through seven consecutive years, one cannot help being impressed with the tenacity with which these birds cling to their favorite nesting locality. The variation in the eggs of this species, and especially this pair of birds, is noteworthy. From almost unmarked specimens one may find gradual variation to eggs which show almost no trace of the ground color and whose spots are in places almost black. Some show sharp contrasts, while others lack it entirely. This series of sets consists of thirty-three eggs and contains two sets of six, one of five and four sets of four eggs each. Probably nowhere in the United States is there a more complete and interesting series of sets of this particular species.

The longest egg measures 2-3.96 inches, while the shortest is 1-78.96, a difference of 21.96 inches. In breadth the variation is almost as great, the broadest being 1-66.96, the narrowest 1-47.96, a difference of 19.96 inches. The variation in number is also great, three being the smallest complete set and six the largest.

In no case where a second set was laid did the number exceed three. Unfortunately no measurement of the second set laid were secured, and this prevents us from knowing whether these eggs were smaller in size as well as fewer in number than the first sets.

The food, so far as observed, consisted entirely of birds, and at least four different species are known to have been taken, The increasing popularity of the Palisades as a summer resort, together with the presence of a large stone crusher located near the cliff where these noble birds once nested, precludes the likelihood of their return to this once favored locality.

SIGNIFICANCE OF THE OCCURRENCE OF MINUTE QUANTITIES OF METALLIFEROUS MINERALS IN ROCKS.

BY CHARLES R. KEYES.

The present consideration of the occurrence of many of the more common metals in minute quantities in the rocks had its foundation in an inquiry started by Messrs. Winslow and Roberson, in connection with the investigation of the Lead and Zinc deposits in Missouri, undertaken by the geological survey of that state. Although the work of these authors ended with their general report, the special phases of the investigation were not dropped by the survey. While the later results are by no means complete as yet, owing at that time to circumstances entirely beyond the control of the scientific corps of the organization, it is believed that there were some points reached in sufficient detail to make a general statement worthy of representation in synoptic form.

The lead and zinc deposits of southern Missouri and the contiguous parts of the adjoining states are of more than ordinary interest at this time, for the reason that they present, in an exceptionally fine way, many of the most instructive phases of ore-genesis.

The recent discussions on the ore deposits by the geologists have awakened a new interest in the whole subject, and clearly indicate that the time is opportune to begin the consideration of systematic plans of inquiry, to devise special methods of work, and to formulate critical criteria which will enable all investigations to be brought to a satisfactory basis for comparison.

The observations herein recorded are offered chiefly in criticism of certain methods of inquiry which are com-

monly followed in attempting to determine the amounts of ore materials that rock masses are supposed to contain. The endeavor is further to show that in the usual analysis of rock materials for the metallic content, as an explanation of the immediate source of the ores, there is a serious fundamental error, both in manner of procedure and in the premises of the logical inference. In many cases the results obtained have been not only indecisive in their nature, and misleading in fact, but they have, in reality, millitated directly against the very propositions they were intended to prove.

Stelzner and Posepy, in their attempts to show that the results of Sandberger, Becker and others are in error regarding the mineralogical source of ore minerals, have manifestly allowed their zeal to swing the pendulum as much too far in the opposite direction as they believed their opponents had in the other. In particular cases, Sandberger may be wrong in his conclusions, and his methods may be indecisive in character, as Posepy claims. But some of the assumptions of the latter regarding the primary nature of certain metallic rock-forming minerals cannot only not be proved, but the exact contrary has been thoroughly demonstrated. There is an element of probable error in the methods of these rivals; and it only differs somewhat in kind.

Some of these features may be pointed out later in connection with the references to the modern microscopical examinations of rocks. While it may be shown that the metallic content of igneous rocks is a far more important factor than is often supposed, the attainment of definite data is an effort much more complex than has been generally believed.

At the present time, it is generally conceded that an important primitive or ultimate source of the metals is the igneous rocks, either those already at the surface or deep-seated bodies, solid or molten, but it is not considered that the concentration of the metallic substances into ore-bodies is in any way always connected necessarily with volcanic activity.

The explanation of ore-deposits lies neither wholly within an aqueous theory, nor wholly within an igneous theory. It lies rather between the two, or combines both.

The most recent rock analyses, in which the rarer elements have been especially tested for, show appreciable amounts of substances which ordinarily are calculated in with more abundant compounds. In these new experiments the microscope has been of inestimable value. These more modern refinements in rock analysis demonstrate beyond all doubt that many of the less common metals and rare earths exist in some form or other in nearly all crystalline rocks, and in most of them in much greater abundance than has been generally supposed.

In the old pre-Cambrian igneous rocks of Missouri, which have not been affected by orogenic movements to any appreciable extent, and where surrounding conditions appear to preclude the secondary introduction of metallic salts, Robertson found measurable quantities of lead, zinc, copper and manganese. It is a noteworthy fact that the percentages of the metals increased rapidly with the increase in the amount of ferro-magnesian silicates present, in the rocks. The diabases contained five times as much metal as the granites poor in dark mica. Another feature to be noted is the fact that while lead and zinc occur in about equal proportions, amounting to, in some cases as in the diabase of Shrainka, one-half of one per cent of the constituents soluble in nitro-hydro-chloric acid, the last mentioned is almost wholly absent among the ore deposits of the eastern slope of the Ozark dome, where the first mentioned metal is the chief ore.

Most of the attempts to determine the metallic element of the rocks have been through chemical analysis. For the purpose of reaching definite conclusions, the results as a whole have been far from being satisfactory. So far as the chemical methods and manipulation go, results have been exact enough, but there are sources of error which have not been guarded against which lie beyond the sphere of the chemist.

In the long list of published analyses of the crystalline rocks, the feature most striking to the student of ore deposits is the apparent absence of metallic elements. Several factors contribute to this apparent anomaly. In the first place the majority of rock analyses have been made primarily to establish the relationships of the non-metallic elements composing the rock forming materials. The percentage sum of the minerals leaves a very small margin for the minerals which from a strictly metallurgical standpoint are important. With the exception of iron and one or two other metals, no account is taken of the metallic elements which may be present.

The fact is well illustrated by the Missouri rocks. The Graniteville granite, when analyzed for petrographical purposes showed no metals other than iron and maganese. When tested by more refined methods, the identical rock was found to contain 0.00126 per cent of lead, 0.00216 per cent of zinc and 0.00176 per cent of copper.

Owing to the usual methods of analysis these, if they be present, are calculated as iron or some other metal. This is sufficiently close for the immediate purpose of petrography. It is in fact all that is demanded of the rock student. Analysis more refined is entirely unnecessary in rock investigations.

It is a fact that has attracted wide attention that the results of the more recent rock analyses present a very different aspect from that of the earlier and majority. Some of these have been undertaken with the express purpose of determining those metallic elements which occur in very minute quantities; others have been made with the view of getting more exact statements for special features. In nearly all of these the presence of several of the rarer metallic compounds is a feature that is quite noteworthy.

An exhaustive critical review at this time, of what has been done in regard to this phase of the subject, would be out of place. The comparatively few examinations which have been made with the special object in view of determining the character of the metallic contents of rocks have

all been singularly indecisive in results. The extraneous sources of error have not been guarded against. Far too much has been assumed. Not only has the work been not determinative, but in the published accounts the most important point of all, that of the geological conditions, has been scarcely ever touched upon.

To be sure, problems of this kind are beset with many difficulties. Many factors have to be taken into consideration. There are theoretical conditions imposed that have to be fully satisfied before actual examinatians can be of much value. Singularly enough, existing critical data on the subject have not come from those sources in which special effort has been made to obtain the desired results. They have been derived entirely in connection with microscopical petography, incidentally, as it were. There are strong logical reasons, as well as practical reasons, for believing that in the case of the igneous rocks the question can only be definitely disposed of through means of the microscope.

GENESIS OF CERTAIN CHERTS.

BY CHARLES R. KEYES.

As regards origin, the cherts which occur so abundantly throughout the limestones of the lower carboniferous of the Mississippi valley have been the subject of much speculation. The same problem has received attention from every quarter of the globe. While the explanations offered differ very much from one another they in general agree in that they are regarded as formed contemporaneously with the geological formations in which they occur. The writings of Prestwich, Irving, Van Hise, Hull, Benard, Hinde, Hardman, Hovey, and many others corroborate this statement.

That the cherts may have been secondary features, formed long after the rocks containing them were laid down and consolidated, does not seem to have occurred to any of the writers mentioned. That some of the Carboniferous cherts of Iowa and Missouri have been formed in the rocks long after the latter were formed there is small doubt, as subsequent statements will conclusively show. How extensive this secondary mode of chert formation is, is not as yet definitely known. It is believed that the process is of wide application, if not universal, so far at least as concerns the Carboniferous cherts of the two states mentioned.

In southwestern Missouri, in the mineral belt, the cherts constitute extensive layers interbedded with limestones. In many cases the proportion of chert greatly exceeds that of the limestone. So marked is this preponderance of silicious beds that the formations or terranes are called "cherts" in place of "limestones."

Were one to study the cherts of southwest Missouri alone, he might long look for evidence for any other explanation of genesis than that of a formation contemporaneous with the geological terrane. We get an important clue, arguing for non-contemporaneity of formation of the chert and inclosing limestone, in a consideration of the lower carboniferous terranes of southeastern Iowa and northeastern Missouri, when the chert constitutes a comparatively small part of the whole terrane.

Careful comparisons of the fossils from these cherts and those of the surrounding limestones show that the forms to a great extent are identical. Moreover, numerous shells and crinoids are found partly imbedded in the chert and partly in the limestone, and fossils likewise half chert, half limestone, with a sharp line of separation, indicating clearly that the silicious impregnation was acquired long after the original deposition of the beds, and was not due to a greater silicity of the waters in which the calcareous deposits were made, as has been held by many prominent writers. This is in accordance with observations made elsewhere in the Burlington limestone.

Considering in this light the cherts of the Missouri mineral belt in the southwestern part of the state similar conditions appear to have prevailed. The calcium carbonate of the fossils is found entirely replaced, one end only replaced, or only a small part replaced, by chert. A similar replacement also takes place in which iron sulphide is substituted for the original material of the fossils. Likewise zinc sulphide, the principal ore of the district, is found composing fossils as perfectly as in the original, every structure being perfectly preserved.

From these facts, and many others, no other conclusion can be reached but that the cherts were formed long after the terranes were laid down; that the cherts were formed under the same conditions as the ores of the region, and that, like the ores, the cherts were formed at a comparatively recent date; that, as in the case of the ores, the cherts were formed by the displacement of the original limstone molecule by molecule.

The formation of the ores of the region is going on rapidly at the present time. The last uprising of the Ozark dome is not believed to be yet finished. The formation of ore and chert is manifestly very recent, geologically speaking. It is not impossible, but not probable, that the whole transformation may have taken place within the memory of man.

COMPARATIVE VALUES OF DIFFERENT METHODS OF GEOLOGIC CORRELATION IN THE MISSISSIPPI BASIN.

BY CHARLES R. KEYES.

(Abstract.)

The need of a number of independent criteria in the broader work of geologic correlation has never been more apparent than at the present time. Yet for necessary

reasons geologists have been slow in applying in the field what they have been convinced of in their theoretical musings.

In those cases in the Mississippi valley in which several correlative tests have been made simultaneously, some very instructive features have been disclosed. A paper on the results of one of their multiple tests was read before the Academy last year, and a more extended memoir, on a closely similar topic was also read before the Geological Society of America, entitled the "Devonian Interval in Missouri."

In geological correlation the most important of the criteria which have been most generally employed may all be assigned to two main groups, the biological, or biotic, and the physical. At one time or another each one of the subordinate methods of both groups has been made all-decisive in the various plans of geological work. At the present time all of these are used to some extent, either directly or indirectly. These minor methods have been recently arranged by Gilbert in the following way:

I. Physical, through
- (1) Visible continuity.
- (2) Lithological similarity.
- (3) Similarity of lithological sequence.
- (4) Unconformities.
- (5) Simultaneous relations of diverse deposits to some physical event.
- (6) Comparison of changes deposits have experienced from the action of geological processes supposed to be continuous; and

II. Biotic, through
- (7) Relative abundance of identical species.
- (8) Relative abundance of allied or representative species.
- (9) Comparisons of faunas with present life.
- (10) Relations of faunas to climatic episodes.

With possibly one exception, all the methods of correlation which are included in the two principal categories are strictly local in their scope, though it is the custom to

regard them as applying widely, if not universally. For many years general correlations have been carried on almost entirely by the biotic methods. At the present time they predominate over all others, and are, in fact, the foundation of our commonly accepted system of geological synchrony.

It is beginning to be recognized more and more clearly that organic remains are not the all-deciding factors in questions of correlation; that they are, in reality, merely accidental characters, and that when depended upon they must always be, and are in fact, taken in connection with physical features.

In the Mississippi valley not nearly enough detailed work has yet been done on the fossils to enable exact correlations to be made through the faunas alone. Were it not for the adoption of other and independent methods of correlation, the strata of the region, so far as the paralleling of the different vertical sections is concerned, might for a long time remain in a very unsatisfactory condition.

In the correlation of these strata five distinct methods have been made use of. In consequence, the results obtained by one method have been checked by those arrived at through other independent data. In this way, marked discrepancies in the readings of one set of records have been detected and corrected. The values of the several methods have been quite different in different localities, but when all could be applied in a single district the comparative results have been full of interest. This has been particularly notable in the case of northeast Missouri, in the area occupied by the original Kinderhook.

In order of their practical values in the field work in this district these five methods are similarly of lithologic sequence, lithologic similarity, faunal comparison, orotaxis, and homogeny.

THE CHEMICAL COMPOSITION OF NUTS USED AS FOOD.

BY J. B. WEEMS AND ALICE W. HESS.

[*Contribution from the Department of Agricultural Chemistry, No. 4, Iowa State College.*]

Nuts are used extensively as a luxury and their food value has been given little attention. According to the report of the department of agriculture, nuts are imported to the value of $1,518,484 in 1901, and this amount does not include the nuts which are admitted duty free. The use of nuts under the unfavorable conditions for digestion has given to them a reputation of being indigestible. If used under favorable conditions as part of the meal and not as an addition to a product which is indigestible itself, there is no reason why many of the nuts should not be regarded more favorably as food. The cost of nuts in this state places them among the luxuries, since they cannot be regarded as an economical food material, except possibly the peanut. Compared with the more expensive forms of breakfast foods many of the nuts are not expensive forms of food.

The analyses of the nuts which have been made in connection with this study include the native nuts and those found on the market. There are other nuts besides those that have been selected which it is hoped will be added to the results given in this paper at some future time. As a matter of interest the chufa nut has been included in the analyses. While the chufa nut is not found in the market yet, it is advertised by seedmen as a nut which readily grows in Iowa. The results of the analysis made by the Maine Experiment Station [1] are of interest in connection with this study.

(1) Report Maine Experiment Station. 1899, p. 87.

ANALYSIS OF NUTS MADE BY MAINE EXPERIMENT STATION.

	Refuse.	Edible portion.	EDIBLE PORTION. Water.	Protein.	Fat.	Carbo-hydrates.	Ash.	Full value per pound.*
	pr. ct.	pr. ct.	pr. ct.	pr. ct.	pr. ct	pr. ct.	pr. ct.	Calories
Almonds	64.8	35.2	1.7	7.3	19.3	6.2	.7	1665.
Almonds, kernels	.....	100.0	4.8	21.0	54.9	17.3	2.0	3030.
Brazil nuts	49.6	50.4	2.7	8.6	33.6	3.5	2.0	1545.
Filberts	52.1	47.9	1.8	7.5	31.3	6.2	1.1	1575.
Filberts, kernels	.....	100.0	3.7	15.6	65.3	13.0	2.4	3290.
Hickory nuts	62.2	37.8	1.4	5.8	25.5	4.3	.8	1265.
Pecans	49.7	50.3	1.5	5.2	35.6	7.2	.8	1735.
Pecans, kernels	......	100.0	2.9	10.3	70.8	14.3	1.7	3445.
Walnuts	58.0	42.0	1.2	7.0	27.0	6.1	.7	1385.
Walnuts, kernels	......	100.0	2.8	16.7	64.4	14.8	1.3	3305.
Chestnuts	16.1	83.9	31.0	5.7	6.7	39.0	1.5	1115.
Peanuts, raw	26.4	73.6	6.9	20.6	30.7	13.8	1.6	1935.
Peanuts, kernels	......	100.0	9.3	27.9	42.0	18.7	2.1	2640.
Roasted peanuts	32.6	67.4	1.1	20.6	33.1	10.9	1.7	1985.
Shelled peanuts	.	100.0	1.6	30.5	49.2	16.2	2.5	2955.

* Calculated from analysis.

CHEMICAL COMPOSITION OF IOWA NUTS.

NAME.	Refuse.	Edible portion.	Waste in cracking.	Edible portion: Water.	Edible portion: Ether extract.	Edible portion: Crude fiber.	Edible portion: Protein.	Edible portion: Ash.	Edible portion: N. Free extract.	Edible portion: Fuel value per pound. (4).	In dry matter: Ether extract.	In dry matter: Crude fiber.	In dry matter: Protein.	In dry matter: Ash.	In dry matter: N. Free extract.
*Native hickory nut (Carya alba)	68	30	2	1.20	19.38	.69	6.15	.66	1.92	968.	20.19	.72	6.40	.69	2.00
*Native hickory nut kernels	.....	....		3.97	64.00	2.30	20.50	2.20	6.40	3226.	67.29	2.40	21.35	2.29	6.67
*Native walnut (Juglans nigra)	76	22	2	.83	13.66	.51	2.11	.60	4.29	805.	14.21	.53	2.22	.62	4.42
*Native walnut kernels	.....	....	.....	3.80	62.10	2.30	9.60	2.70	19.50	3158.	64.60	2.40	10.10	2.80	20.10
†English walnut	57	43	.....	2.88	23.24	.90	8.29	.86	6.83	1305.	24.90	1.01	8.88	.91	7.30
†English walnut kernels	.....	.....	.....	6.70	51.05	2.10	19.28	2.00	15.87	3837.	57.98	2.36	20.66	2.14	17.01
†Almonds	40	60	.....	3.12	29.52	1.76	13.74	2.10	9.76	1682.	31.14	1.86	14.52	2.22	10.26
†Almond kernels	.....	.....	.....	5.20	49.20	2.93	22.90	3.50	16.27	2803.	51.90	3.10	24.20	3.70	17.10
†Filberts	65	35	.....	1.23	22.33	1.12	5.18	1.05	4.09	1118.	23.14	1.16	5.36	1.09	4.25
†Filbert kernels	....		.....	3.50	63.80	3.20	14.80	3.00	11.70	3195.	66.10	3.31	15.34	3.11	12.14
†Pecans	53	47		1.31	34.12	.99	4.60	.80	5.18	1620.	35.11	1.01	4.74	.82	5.32
†Pecan kernels	...	.....	.....	2.80	72.60	2.10	9.80	1.70	11.00	3451	74.70	2.10	10.00	1.70	11.30
†Unroasted peanuts	27	70	3	2.31	34.37	2.24	19.11	1.63	10.36	1998.	35.55	2.32	19.76	1.66	10.71
†Unroasted kernels	.....	...	.....	3.33	49.10	3.20	27.30	2.20	14.80	2855.	50.78	3.31	28.28	2.37	15.31
†Roasted peanuts	30	69	1	.62	35.33	2.07	19.18	1.65	10.15	2043.	35.66	2.09	19.35	1.62	10.93
†Roasted kernels	.....	.....	.....	.90	51.20	3.00	27.80	2.40	14.70	2961.	51.66	3.03	28.05	2.42	14.84
§Chufa nuts			.....	23.36	24.34	9.96	5.02	2.84	34.48	1762.	31.75	12.98	6.55	3.70	45.02

*Gathered at Ames in 1900; analyzed in 1901.

†Bought in Ames and analyzed in 1901.

§From Boone, Iowa, 1898.

(4). Calculated from analytical results,

In the study of the results we see that the native nuts have a much larger percentage of refuse than the others, and with the exception of the chufa nut, the unroasted peanuts have the smallest amount of waste. The native walnuts having 76 per cent of refuse and the unroasted peanut with 27 per cent are the extremes.

The chufa nuts at the time of analysis contained a very large amount of water. In the other nuts the amount of water does not exceed 3.12 per cent in the almonds as purchased, while the english walnut kernels contain 6.70 per cent. The fat or ether extract is present to the greatest extent in natural nuts of 35.33 per cent in roasted peanuts, and the lowest in the native walnut of 13.66 per cent. The kernels of the pecan contain, however, 72.60 per cent of fat, the largest percentage of any of the nut meats, and the unroasted peanuts 49.10 per cent for the lowest.

The protein is present in the roasted peanuts to the amount of 19.18 per cent, as purchased, and 27.80 per cent in the kernels. The native walnut has the smallest amount of protein, 2.11 per cent, as gathered, and 9.60 per cent in the kernels. If the value of the nuts for the amount of starch, sugar, etc., present should be desired, the unroasted peanut with 10.36 per cent of carbo-hydrates will be found to be the highest in the nuts as purchased, if we except the chufa nut, which has 34.48 per cent. In the kernels, however, we find that the almond with 19.50 per cent, is highest of the common nuts. The hickory nut has the smallest amount of carbo-hydrates as gathered, 1.92 per cent, and the kernels 6.40 per cent. On comparing the nuts for their fuel value, they may be arranged in the following order: roasted peanuts, unroasted peanuts, chufa nuts, almonds, pecans, english walnuts, filberts, hickory nuts, and walnuts. The peanut is undoubtedly a valuable food material, and its reasonable price readily places it as the most useful of the nuts commonly met with in the market.

THE PREPARATION OF AMMONIA FREE WATER FOR WATER ANALYSIS.

BY J. B. WEEMS, C. E. GRAY AND E. C. MYERS.

[*Contribution from the Department of Agricultural Chemistry, Iowa State College, No. 5.*]

The preparation of water which will not give the yellow coloration with Nessler's reagent is an important problem in the analysis of water. Where the laboratory water supply contains a small quantity of ammonia, suitable water for use in water analysis can no doubt be obtained by ordinary distillation and collecting that part of the distillate which is free from ammonia. The water supply of many laboratories will not permit of this ready method of preparing ammonia free water. The distilled water must be redistilled with sulphuric acid and potassium permanganate to obtain a satisfactory water which will remain colorless when the Nessler reagent is added to it. This method requires distillation in a glass flask and is subjected to the usual degree of breakage and loss.

Recently a method has been proposed for the preparation of water for water analysis which has the advantage that redistillation is not necessary. The method is as follows:

(1). "One or two liters of ordinary distilled water is placed in a stoppered bottle and a little bromine vapor is then poured into it. After shaking, the water should be just perceptibly tinted and should give a blue coloration when dropped on iodide and starch water. One drop of a strong solution of caustic soda is now added and the bottle again shaken and placed aside for ten minutes. Finally, one or two drops of a solution of potassium iodide are

(1). Journal Society of Chemical Industry, 1896, p. 255.

added and the water will be free from ammonia and suitable for Nesslerizing purposes."

In our experiments we have found that the water prepared by this method has been unsatisfactory, and probably due to the addition of potassium iodide. The presence of the iodide apparently destroys the sensitiveness of the Nessler reagent. While this method may be satisfactory under certain conditions, it has been found without value for work in this laboratory. The following method is suggested for the preparation of water free from ammonia and nitrogen as nitrates and nitrites.

Sodium peroxide is added to the water in an ordinary round bottom flask, in the proportion of one dram to each liter of water. Flasks of five or six liters in capacity are found to be very satisfactory. The contents of the flask is boiled for thirty minutes or longer, until it is estimated that the water is free from ammonia. The time for boiling and the amount of sodium peroxide will vary according to the amount of ammonia which may be present in the water. If it is desired to prepare water that is free from ammonia and nitrogen as nitrates and nitrites in order that one supply may serve for making standards for the determination of ammonia, nitrites and nitrates, the contents of the flask are transferred to a copper distilling vessel and distilled. The first portion of the distillate is rejected and the remainder kept in bottles in the usual manner.

THE PREPARATION OF PHENYL ETHER.

BY ALFRED N. COOK.

While ethyl ether, the common ether of the modern drug store, has been known for three and a half centuries, and has been used as an anesthetic for over fifty years, phenyl ether is of more recent origin. It has never been put upon the market and has never been put to

any so-called "practical use." Improved methods of preparation, however, may bring it within reach of the physiological chemist or the manufacturer, so that this substance or some of its immediate derivatives may, 'ere long, play an important part in the economy of men.

Phenyl ether was discovered by List and Limpricht[1] in 1854, while studying the products of the destructive distillation of copper benzoate. They did not identify it as phenyl ether, but assigned to it the empyrical formula $C_{12}H_9O$, derived from the results of their analysis. Why this formula was assigned to it is difficult to see, for their analyses correspond much better with the formula now assigned to phenyl ether. Acting on the suggestion of Gearhardt, Limpricht[2] later assigned the formula $C_{12}H_{10}O$ and called the substance the ether of carbolic acid. The compound was next studied by Rudolph Fittig[3] and later Kekule' in his Lehrbuch suggested, on the ground of Fittig's work, that it was monohydroxy diphenyl.

C. Lesimple[4] prepared a compound which he supposed to be phenyl ether, by distilling phenyl phosphate with lime, but Hoffmeister,[5] afterwards showed that it was diphenylene oxide.

C. Clem[6] attempted, without success, to prepare phenyl ether by heating potassium phenolate and potassium benzoate.

Since the discovery of phenyl ether in 1854, perhaps thirty different German, English, and American chemists have given the subject more or less attention. The French have not yet entered the field.

Aside from the above method of List and Limpricht for preparing phenyl ether, six other direct methods have been employed, as follows:

Hoffmeister[7] obtained a small yield by means of the diazo reaction with phenol, aniline, and sulphuric acid.

[1] Annalen der Chemie XC, 190.
[2] Lehrbuch, page 718, and Annalen der Chemie CXXV, 328.
[3] Annalen der Chemie, CXXV, 328.
[4] Annalen der chemie, CXXXVIII, 276.
[5] Berichte, III, 747.
[6] Jr. fuer Pract. Chem., 1870, 147.
[7] Annalen der Chemie. CLI, 194, and Berichte III, 747.

Hirsch[8] used the chloride instead of the sulphate, and claimed to have obtained a yield equal in weight to 50 per cent of the aniline used. He suggests that the cause of the small yield obtained by Hoffmeister was due to the formation of phenol sulphonic acid.

Merz and Weith[9] obtained a yield of six per cent of theory by heating phenol with zinc chloride, and also a small yield by heating phenol with aluminium chloride.

Gladstone and Tribe[10] obtained a good yield by distilling alluminium phenolate.

B. Jeitles[11] obtained phenyl ether by distilling calcium phenyl salicylate

Klepl[12] prepared phenyl ether by distilling para-phenoxy benzoic acid with caustic baryta.

Richter[13] obtained phenyl ether by distilling sodium salicylate with triphenyl phosphate.

During the past three years, in company with some of my advanced students, I have been studying the preparation of derivatives of phenyl ether by means of a method which is of general application in both the fatty and aromatic series—that of heating a halogen-nitro-benzene with a potassium phenol. The results were published in part in the PROCEEDINGS OF THE ACADEMY, but mostly in other journals.

As I was about to begin the study of derivatives of phenyl ether by direct methods it was important to obtain the substance in considerable quantities. Having attempted to follow out several original ideas of my own without avail, I began to study the methods of those who had already prepared the substance and selected the method of Hoffmeister, as modified by Hirsch, and that of Gladstone and Tribe as the most promising.

[8] Berichte XXIII, 370.
[9] Berichte XIV, 187.
[10] Jr. Lond. Chem. Sac. XLI, 5.
[11] Monats Hefte 17, 65.
[12] Jr. Pract. Chem. (2), 28, 193.
[13] Jr. Pract. Chem. (2), 28, 201.

THE HIRSCH-HOFFMEISTER METHOD.

The method as carried out by Hirsch was as follows: A 90 per cent solution of phenol was warmed on a water bath in a flask fitted with a return condenser and the diazobenzene chloride solution added through the reflux condenser by means of a separating funnel with sufficient rapidity to cause an active, but not too violent, reaction. When all was added the temperature was finally raised to 90°. The resulting solution was salted out with a concentrated solution of sodium chloride and the liquid precipitate fractionated by distillation. The portion boiling above 200° C was dissolved in toluene and washed with a solution of sodium hydroxide. This solution on being fractionated yielded phenyl ether, boiling between 260° and 290° C, and a neutral oil in small quantity boiling between 320° and 350° C, which he supposed to be diphenyl phenyl ether, $C_6H_5 - O - C_{12}H_9$., although he did not analyze it. He states that under certain circumstances he obtained a yield of phenyl ether equal in weight to 50 per cent of the aniline used. He did not, however, describe the circumstances under which he obtained it.

I carried out the process in all respects essentially like the above, except that no return condenser was found necessary, and that part of the distillate containing the phenyl ether was not dissolved in toluene for washing with caustic soda, but was washed directly with the sodium hydroxide solution. No loss of phenyl ether could have taken place, as the soda solution was very weak, and phenyl ether is almost entirely insoluble in water. It is soluble, however, in a very strong solution of sodium phenolate, but is precipitated on adding a considerable amount of water. The degree of dilution of the sodium phenolate solution would entirely prevent any appreciable loss by this method of washing. Three experiments were made, and in each case a large quantity of phenol was recovered. *First experiment:*

AMOUNTS OF SUBSTANCES EMPLOYED.

Aniline	100 grams.
Concentrated hydrochloric acid	325 grams.
Water	900 grams.
Sodium nitrate, a sufficient quant ty to diazo'ize the aniline.	
Phenol containing 10 per cent of water	550 grams.

When a portion of the diazo solution was added to the phenol, warmed to 65° C, nitrogen was evolved quite rapidly, and very rapidly at 85°. Most of the diazo solution was added at the higher temperature. When 100 c. c. of the diazo solution was added to the phenol solution it took only a few minutes to evolve its nitrogen.

On distilling, the phenol with one or two other substances came over below 210°, when the temperature rose rapidly to 260°, where the higher boiling substances began to come over. As a final result there were obtained a few grams of a substance having the odor of geraniums and boiling at 250°. This was undoubtedly phenyl ether. There was also obtained 40 grams of a crystalline solid, boiling between 275° and 280°. This substance was obtained by neither Hirsch nor Hoffmeister. No attempt was made to purify or analyze this substance or the one mentioned further on, as the chief object of this research was to obtain a considerable quantity of phenyl ether. The neutral oil mentioned by Hirsch, boiling between 320° and 350° C, and which he suggested to be diphenyl phenyl ether, was not obtained. A very small quantity of tar remained at the end of the first distillation.

On fractionating the portion boiling below 210°, there was obtained a liquid not soluble in caustic soda, which boiled a few degrees higher and melted a few degrees lower than phenol. It crystallized in long needles on standing at room temperature. This substance was not mentioned by Hirsch. It would be easily overlooked, since it distills over with the phenol, but mostly with the last portion. However, it may not have been formed in his experiments since he kept the temperature considerably lower than in this experiment during the addition of the diazo solution to the phenol. While I

did not study the compound exhaustively, I think it likely has the formula, $C_6H_5N_2\ NH.C_6H_5$. I do not know that this compound has been obtained up to this time, but the corresponding para-toluidine compound is known. On fractionating the substance several times a portion weighing several grams was obtained, which boiled between 180° and 182°. On standing decomposition took place. When first prepared it had no odor and was colorless, but on standing for three months it became dark in color and had a strong odor of phenol. All but a few globules dissolved in caustic potassa. These globules had the characteristic odor of phenyl ether. There was not enough of this oil to collect and determine its melting point. The change took place in two portions, one in an open flask and the other in a full and tightly corked bottle. The action was not, therefore, due to the oxidizing action of the air.

Second experiment:

Quantities taken,

Aniline	100 grams.
Concentrated hydrochloric acid	200 grams.
Water	700 grams.
Phenol containing 10 per cent of water	500 grams.

The diazo solution was added slowly while the phenol solution was heated to 53°—63°. This was the only difference between this trial and the preceding one.

Results were obtained as follows:

1. None of the substance boiling at 180°--182°.
2. About eight grams of purified phenyl ether.
3. Much less of the crystalline solid.
4. A great deal of tar.

Third experiment:

Quantities taken,

Aniline	100 grams.
Water	1,000 grams.
Phenol containing 10 per cent of water	450 grams.
Concentrated hydrochloric acid, sufficient to diazotize the aniline.	

In this experiment the phenyl ether was distilled from the higher boiling substances with steam. The yield was

fifteen grams of the purified ether. This was much better than the results obtained by Hoffmeister, but much less than was claimed by Hirsch.

The process is long and tedious, and the returns so relatively small that it was thought best to give attention to other promising methods.

THE GLADSTONE–TRIBE METHOD.

Gladstone and Tribe obtained phenyl ether and two or three other compounds by distilling aluminum phenolate, prepared by acting on phenol with aluminum, in the presence of iodine as a catalytic agent. They estimated that one-half of the aluminum phenolate was decomposed by the action of heat into phenyl ether and aluminum oxide. That being the case, the distillation of aluminum phenolate would be an excellent method by which to prepare phenyl ether, providing the aluminum phenolate could be easily obtained.

Preparation of the Aluminum Phenolate.—Five hundred grams of phenol containing a gram or so of iodine in a flask fitted with a return condenser was heated over a direct flame, and the aluminum, in the form of strips, *very* slowly added. It was found necessary to obey this precaution very carefully, since, when considerable quantities of aluminum were added at a time, the action was so violent that the heat of reaction raised the phenol to its boiling point and volatilized it so rapidly that it projected from the tube uncondensed.

Properties of Aluminum Phenolate.—The solid substance is brittle and possesses a vitreous luster and conchoidal fracture. Prepared as given above, it is usually black, but sometimes gray. It is soluble in hot xylene, from which it separates as a gelatinous mass on cooling, and Gladstone and Tribe found it to be soluble in benzene. If bottled tightly it can be kept for a long time without undergoing any change, but if allowed to come in contact with the air it very soon loses its vitreous luster and crystalline grains appear throughout the surface of the fragments. It

becomes moist and smells strongly of phenol, whereas, when freshly prepared, it has no odor. Evidently either the oxygen or the moisture of the air (most probably the latter, but possibly both), acts upon it with the liberation of phenol and the formation of aluminum oxide. The reaction is probably represented by the following equation:

$$2\,Al(O\,C_6H_5)3 + 3H_2O = Al_2O_3 + 6HO.C_6H_5.$$

The phenol is probably simply held mechanically, and the crystalline grains are probably aluminum oxide.

When distilled it did not melt down as fresh aluminum phenolate does, but remained in the powdery form in which it was placed in the flask, throughout the distillation, nor did the particles run together in the least. It apparently distilled at a lower temperature than fresh aluminum phenolate. From 123 grams of the substance there resulted 89 grams of the distillate and 34 grams of a powdery residue, which was poured from the flask as so much sand. On redistilling this distillate a portion came over below the boiling point of phenol, which had the characteristic odor of benzene. Most of the substance, however, came over at 179°—180°, the boiling point of phenol. There were no higher boiling substances formed. The *odor* of phenyl ether which is so conspicuous in the phenol that results from the destructive distillation of aluminum phenolate, was not observed. The process of distillation evidently simply separated the mechanically held phenol with a little dissolved benzene from the aluminum oxide and other residue.

The distillation of the aluminum phenolate was carried out in a distilling flask containing from 100 to 200 grams of the substance. The products of distillation are a very small quantity of benzene (which, however, may have resulted from the reducing action of the nascent hydrogen on the phenol during the process of manufacture of the aluminum phenolate, and may have been simply held mechanically in the impure aluminum phenolate), a varying amount of phenyl ether, and some higher boiling substances not yet identified. Gladstone and Tribe purified

and analyzed one of them which boiled at 280° and melted at 97°, and which they supposed, from the results of their analysis, to be diphenyl ketone, but this substance, according to Watts' Dictionary of Chemistry, page 474, boils at 305°, and melts at 48°. It is safe to say, however, that none of these higher boiling substances have yet been identified.

The degree of heat employed should be as low as possible in order to obtain a large yield of phenyl ether. There is also obtained a relatively larger amount of tarry residue. When a high degree of heat is employed the aluminum phenolate decomposes mostly into phenol and the higher boiling substances. There results, however, much less of the tarry residue. By heating the flask as uniformly as possible at the close of the operation and carrying the distillation as far as possible, a porous residue remains, which can quite readily be removed from the flask when cool; otherwise a hard asphalt-like residue remains, which it is impossible to remove without sacrificing the flask.

Gladstone and Tribe estimated from their results that one-half of the aluminum phenolate decomposed, on heating, into aluminum oxide and phenyl ether, according to the following equation:

$$2Al\,(OC_6H_5)_3 = Al_2O_3 + 3C_6H_5 - O - C_6H_5.$$

While the reaction probably goes on according to this equation it would seem from their results as well as my own, that this is too high an estimate. From having carefully gone over the work a number of times it would seem that about one-fourth of the aluminum phenolate is decomposed into aluminum oxide and phenyl ether at a low heat. While this method did not yield quite the results hoped for on reading the article of Gladstone and Tribe, it still proved to be a very good method, and is much more easily and quickly carried out than the Hirsch-Hoffmeister method, and the materials are cheap. From 1,227 grams of aluminum phenolate I obtained over 200 grams of pure phenyl ether boiling between 249°—251°,

and which crystallized readily at room temperature. This is undoubtedly the best and cheapest method that has yet been used for the preparation of phenyl ether.

"The preparation, properties, and products of the destructive distillation of aluminum phenolate" are now being investigated in company with an advanced student in the chemical laboratory of Morningside College, and will be published as a separate paper at some future date.

THE SIOUX CITY WATER SUPPLY. II.

BY ALFRED N. COOK AND W. J. MORGAN.

It is designed to continue the examination of Sioux City waters each year for a series of years, and thereby collect valuable data which may be of service in the future. It is yet too soon to draw many general conclusions with sufficient certainty. It will be observed by comparison with last year's results that the analyses of the city water resulted much better this year. The albuminoids ammonia and nitrates have been very much reduced, and the free ammonia entirely disappeared.

The analysis of the Missouri river water suffers by comparison with that of last year, but the specimen was taken near the Floyd monument, which is below the city. The specimen of last year was taken at the combination bridge and was consequently not contaminated with Sioux City sewage.

The specimen from the Sioux river was taken at the boat landing, Riverside park.

The results here given are the average of two or more duplicates. The figures indicate parts per million. All analyses were made in May or the first part of June, 1902.

	City water.	I. N. Stone's well.	Missouri river.	Sioux river.	Manufactured ice.	Sioux river ice.
Total solids	505	450	562	526	94.	110.
Loss on ignition	....	90	....	....	6	20
Chlorides	11.06	6.4	20.	6.47	7.3	4.5
Nitrogen as nitrates	.66	2.	.03	.07	.02	.01
Nitrogen as nitrites	None.	.011	None.	.0544	None.	None.
Nitrogen as free ammonia	None.	.00144	.009	.045	.039	.027
Nitrogen as albuminoid ammonia	.00054	.075	.171	.615	.01	.29
Oxygen consuming power	.1	.5	8.5	2.4	1.5	1 2

THE TOLEDO LOBE OF IOWAN DRIFT.

BY T. E. SAVAGE.

The southern margin of the main Iowan drift sheet extends in a sinuous line across the central portion of Tama county. From this border a tongue-shaped lobe, having an average width of about six miles, extends southward for a distance of eight or nine miles reaching one mile below the city of Toledo and within two miles of the Iowa river. This extension I have called the Toledo lobe of Iowan drift. It is bordered on the west from the point where it leaves the main Iowan drift sheet, about the middle of the south half of section 14 of Carlton township, down to near the middle of section 21 of Toledo township, by the hills which form the west bank of the valley of Deer creek. From the latter point the irregular ridges which mark the margin of the lobe trend to the southeast for one-half mile, and then eastward, continuing in an undulating line near the north side of sections 27, 26, and 25, of the township of Tama. They enter Otter Creek township not far from the southwest corner of sec-

tion 19. From this point they trend in a northeasterly direction across the southern portion of section 19, and bending further to the north they cross the northwest corner of section 20. Otter creek passes through a gap in these hills near the southwest corner of section 17. From here the ridges extend in a general northerly direction, bending alternately eastward and westward, near the west side of sections 17, 8, and 5. They enter Carroll township near the southeast corner of section 31. Continuing northward with a slight inclination towards the west for a distance of five miles, they merge into the morainic hills of the proper Iowan drift plain near the southwest corner of section 6.

This Toledo lobe covers the greater portion of Howard township, a small corner of Carlton, a little more than the east half of the township of Toledo and a narrow strip from the west side of the townships of Otter Creek and Carroll. It is about four and one-half miles in width at the southern extremity, and nearly eight miles across at the north, where it leaves the main sheet. It embraces an area of over 31,000 acres.

Over the southern portion of this lobe the surface is that of a billowy prairie. The elevations seldom exceed twenty feet above the broad channels of the streams. A thin covering of Iowan drift occurs over the lower lands, and in places is found even on the tops of the subdued hills. This drift is of the typical Iowan character. It is yellowish brown in color. The iron which it contains is not fully oxidized, and the calcareous matter is not leached from the surface. It carries but few pebbles or small bowlders as compared with the Kansan, and of these there is but a small percentage of dark colored trap or green-stones.

Over this region the Iowan drift is usually concealed beneath a covering of loess, which varies from a foot or two to several feet in thickness. Such a loess-covered bed of Iowan drift is well exposed along the roadside between sections 18 and 19 of Otter Creek township, and again about the middle of the line which separates sections 33

and 26 of Howard township. The presence of loess overlying Iowan drift is not unique over the state, but this is not its usual mode of occurrence. In central and southern Iowa the deeper beds of loess are found covering Kansan drift at no great distance from the Iowan border. It seems probable that then, as now, loess materials were deposited on the leeward side of obstructions to dust-laden currents of air, or where, in the path of such winds, the soil was covered with vegetation which would serve to catch and retain the dust particles that fell upon it. However, the distribution of loess over this portion of the state would indicate that during the time when the Iowan ice prevailed the conditions were exceptionally favorable for its deposition, and that probably the source of much of the materials might have been the super-glacial silt from the Iowan ice sheet itself.

Very often the deposits of Iowan drift are found in the valleys while till of Kansan age covers the hills and emerges at the surface along the upper part of the slopes. Examples of hills with Kansan drift exposed at the top and having Iowan materials flanking the base, may be seen in the northern part of section 35 of Howard township and along the middle line of section 21 of the same township.

The Iowan ice which pushed down over this area carried quite a large number of light colored granite bowlders. These bowlders are usually from four to eight feet in diameter, but individuals ten to twelve feet in length are not rare, while one specimen was seen with a long diameter of about thirty feet. Bowlder strewn fields, some of the rocks of large size, may be seen about eighty rods south of the Toledo and Cedar Rapids road, one in the eastern part of section 23 and another in the western part of section 24, of Toledo township. Occasional bowlders dot the surface along all of the stream courses over this region. They are seldom found on the higher points, but seem to have been left during the process of the melting of the ice which carried them either on the lower flanks of the slopes or along the beds of the streams.

The topographic features of an area across the middle portion of this lobe are bolder. The tops of the hills stand, in many places, forty to fifty feet above the valleys. The contours are quite sharp and the slopes are steep. The irregular character of these sand or loess capped hills resembles very closely the ridges which are found around the margin of the Iowan drift plain. Even here, however, the stream channels, choked and clogged with aqueo-glacial debris, the occurrence of Iowan drift near the base of the hills, and the presence of large, light-colored granite bowlders along the valleys bear indubitable testimony to the former presence of the Iowan ice sheet. The axes of these hills are composed of Kansan drift, but their tops are usually crowned with sand or with loess, often to a depth of fifteen to thirty feet. A short distance south of the Monticello church, in section 33 of Howard township, the road has been cut through a bank of loess exposing a depth of about fifteen feet while in the valley a short distance away there may be seen a bed of Iowan drift. The loess at this place is very fossiliferous, containing numerous individuals of species of Polygyra, Succinea, Zonites and Pupa. Examples of sand covered hills over this area are numerous, but typical places have been already cited.

The peculiar topography of the Toledo lobe, the presence of loess overlying the Iowan drift, together with the very scant amount of material that the Iowan ice sheet left over its surface would seem to indicate an unusual episode in the history of the Iowan ice action. The phenomena which it presents lend themselves to the following interpretation. During the early stages of the extension of the Iowan glacier a narrow lobe of ice was pushed southward beyond the main body over the deeply eroded Kansan surface, covering the area outlined as the Toledo lobe. For some reason the pressure from behind soon became insufficient to keep up the movement over this lobe, and the ice which covered the region became dead and gradually melted where it came to rest. As the glacier moved slowly over the old Kansan surface, the stones which were held fast along the bottom of the ice would form instru-

ments of attrition of the most effective kind. The materials on the tops of the hills, even though frozen solid, could not but yield rapidly to this grinding action of the ice. The debris worn off from the higher points would be pushed over into the valleys to the leeward of the advancing ice sheet. In this manner the surface inequalities would gradually be reduced, both by the constant wearing down of the greater elevations and by the no less constant filling of the valleys with the materials removed from the tops of the hills. Owing to the short period during which the flow of ice continued over this surface, the tops of the Kansan hills were not subjected to the powerful abrading action of great masses of moving ice for so long a period as were those where the flow continued for the whole time during which the Iowan ice prevailed. As a consequence the pre-Iowan surface here was not planed down to the same extent as it was over the area covered by the main sheet of the Iowan drift.

The generally smooth character of the Iowan drift surface is probably due more to the leveling action of thick masses of ice moving over the region than to the amount of materials transported from great distances which the ice left as it retreated. The Iowan ice did not generally carry such a large amount of drift and debris as the Kansan, as is witnessed by the comparatively thin sheet of materials which is usually found covering the Kansan drift over the main Iowan plain. However, it is probable that the small quantity of ice which melted over this lobe would be one good and sufficient reason for the unusually thin mantle of Iowan materials that is found over its surface.

The cause or causes which resulted in the early cessation of the flow of ice over this lobe did not produce their full effect at once. The movement probably ceased quite suddenly over the southern half of the area, but its withdrawal from the northern portion was accomplished much more slowly and at a much less uniform rate. A halting in the retreat of the ice near the central portion of the lobe, its line of lower limit receding but very slowly through a long period of time, would result in the accumu-

lation around its margin of deposits of sand and loess by the overwash of materials liberated from the melting ice, and by the action of winds sweeping over the surface of the ice sheet and laying down their load to the leeward of its margin.

As a consequence of such deposition the Kansan hills immediately around the border, which had been leveled down to some extent by the ice moving over them, were built up to a height twenty to thirty feet above the more elevated points in the southern portion of the lobe. During this time, also, much of the fine-grained loess materials gathered up by the winds would be carried out for some distance beyond the margin of the ice, and thus the southern portion of the lobe would receive a mantle of loess above the Iowan drift which had been previously deposited over the area. When the ice melted there was left the belt of sand or loess-covered hills, one-half mile to a mile in width, which forms so conspicuous a feature across the north central portion of the lobe.

Some time before the entire withdrawal of the Iowan glacier from the county, the flow of ice ceased over the northern portion of the lobe, the margin retreated to about the same distance southward as that of the main body of Iowan ice. Along this border a new series of ridges was formed, but the width of this belt is less than that of the one which crosses the central portion of the lobe. The individual ridges are also lower and less conspicuous. Pleasant Hill church, situated about the middle of the south side of section 2 of Howard township, is located on one of the ridges of this moraine.

After the retreat of the ice from the Toledo lobe, and probably before the entire withdrawal of the Iowan sheet from this part of the state, a mantle of loess was deposited in places over the northern portion of the area under consideration.

With this deposit and the retreat of the ice the stage of the Iowan ice invasion was closed. From that time, so long ago when measured in years yet so recent from a geological point of view, the forces of weathering and erosion

have modified but slightly the topographic forms of its surface, adding only the last touches to the features which the region presents to-day.

A POSSIBLE ORIGIN FOR THE LIGNITES OF NORTH DAKOTA.

BY FRANK A. WILDER.

The lignite of North Dakota occupies part of an area that is shared by the neighboring states of Montana, Wyoming, and South Dakota, and by Assiniboia on the north. The total area of this lignite field in the United States alone is 70,000 square miles, apportioned as follows:

North Dakota	31,500
Montana	25,000
Wyoming	9,000
South Dakota	4,500

It is probable that all of this field does not contain lignite beds of workable thickness, but studies carried on in North Dakota and Montana during the past summer indicate that thick beds are very general, and that often a series of four or five are separated by relatively thin strata of clay. Some of the beds are very thick, one which outcrops near the Little Missouri in southwestern North Dakota measuring forty feet, while twenty-foot beds are not uncommon.

Analyses of samples taken from more than sixty points in North Dakota show that, except for the high percentage of moisture that they contain, they might be ranked as semi-bituminous coal, since the amount of fixed carbon is unusually high for lignite. The average North Dakota lignite contains thirty-two per cent of moisture. When this is driven off by heating to 100 C., analyses show that the average lignite is composed of:

	Per cent.
Volatile matter	41.5
Fixed carbon	51.
Ash	7.5

The beds, as a rule, show no great lateral persistence. Mining operations have demonstrated that one bed in Ward county underlies fifty square miles of country, but this is believed to be much more extensive than the average. Observations along the Little Missouri and in the Bad Lands, where the lignite beds are often exposed along ravines and canyons for miles continuously, show that the floor on which they were laid down was often uneven, and that they are inclined to thicken or thin out rapidly. While one bed is thinning another may develop above or below it, so that the lignite is continuous through large areas, though there is diversity of beds.

All of the workable lignite beds of North Dakota are regarded as Laramie, though beds a few inches in thickness in the eastern part of the state occur in the Benton. Fossil shells which included three gasteropod and one pelecypod species, collected during the past summer at three points—the same species being found at each point—in clays intimately associated with the lignite, were identified by Mr. Charles Schuchert, of the Smithsonian Institution, who reports that while the range of the species is somewhat extensive, all are indicative of the Laramie. Similar determinations have been made in former years by members of the staff of the United States Geological Survey. As it exists in North Dakota the Laramie consists mainly of clays which are never fissile or shale-like in character. From fat and joint clays they may gradually become arenaceous till they pass into unconsolidated sand. This is locally hardened into solid beds. The most extensive sandstone in the state caps the high buttes in Billings county, and is fifty feet thick. Most of the sandstones are micaceous, the common mica being biotite. Strata which are widely separated laterally and in the vertical scale as well, often show great similarity in composition. They are commonly cross-bedded. The clay strata are marked

by strong individuality in color, and display all shades of gray, brown, red, and yellow, producing effects in the canyons of the Bad Lands that are often exceedingly beautiful. Beds of high grade fire clay which have a fusing point above 3,500° F., are common. A series of clay strata may dip at an angle of ten degrees or more, while those above and below are horizontal. The effect to the eye is not unlike that of cross-bedding.

The lignite is commonly brown in color and exceedingly woody in structure. Tree trunks many feet long and from one to two feet in diameter are often found lying prone in the lignite bed. Unfortunately the bark is never preserved or other characteristics by which they can be identified without the microscope, and as yet microscopic studies have not been undertaken. Small masses of a rosinous-like substance are often distributed through the lignite. Leaf prints and delicate forms have not been found in the lignite itself, but in the associated clays they are well preserved. Specimens taken from a clay which lies between two lignite beds in Ward county were sent to the Smithsonian Institution for identification, and were determined to be:

Sequoia langsdorfii (Brongniart) Heer.
Sequoia brevifolia Lesq.
Sequoia angustifolia Lesq.

Sequoia cones, finely fossilized, were found in great abundance in Morton county. Leaf prints of *Viburnum* perfectly preserved in thin bands of clay-ironstone were found at a number of points.

Unusual opportunities to study the relations of the lignite to the under clay are given, since a great deal of mining is done by the strip-pit system, which leaves the clay bare and shows exactly the line of contact between clay and coal. The extensive exposures in the bluffs of the Bad Lands are instructive in the same way. The underlying clay is practically free from roots. It may contain limbs or trunks, which are scattered irregularly here and there, but these are not uncommon anywhere in the Laramie clays. In not a single instance was a stump found with

roots in the clay under the coal, nor was a case reported by any of the miners interviewed. The clay floor is often uneven. It may dip as much as five degrees when the structure of the overlying clays shows that there has been no folding. It is dotted with low, broad mounds at times and is rarely level.

The purity of some beds is very constant, while the amount of ash in the lignite from others will increase ten per cent and even more in a lateral distance of two hundred yards. So great a change in quality, however, is unusual. Often the upper two or three feet, or even all of a thin bed seems to have decayed, as though after the woody matter had accumulated under water, the lake or swamp under which it was deposited had been partly drained and the lignite exposed to the air for a time before it was covered by silt. The ash in this "soft" lignite is often twenty per cent and it is worthless as fuel. This is as apt to be true of beds low in the Laramie as of those that are near the top.

It is difficult to formulate an hypothesis for the origin of the lignite that is in harmony with all of the facts cited. The ordinary explanation for coal deposits seems inadequate since nearly all of the phenomena on which it is based are absent in this field. There are no roots in, nor stumps rising out of the underlying clays; nor are there delicate leaf prints preserved in the body of the coal, indicating deposition in quiet water. Moreover, the flora of the Laramie, or at least those forms that have been collected from the lignite area and in close connection with the lignite, are of genera which to-day live on dry ground. Many of the beds seem to be made up entirely of wood, with no addition of leaves or the finer forms of vegetation. This wood has suffered so little decay that it is hard to think that the material that forms the upper part of the bed grew upon or derived nourishment from that below, and where the beds are twenty feet thick, not an uncommon occurrence, it is equally hard to conceive of trees growing on ten feet or more of fallen but undecayed trunks, and striking root down into the underlying clay.

In considering drift material deposited in deltas as an origin for coal deposits, the question arises whether sufficient stress has been laid on the probability that considerable quantities of silt and sand would be deposited with the vegetable matter. The conditions must have been unique under which drift timber sufficient to make twenty feet of lignite could accumulate, and yet so little silt be deposited with it that the ash of the lignite is but one or two per cent higher than the percentage of mineral matter in the wood. A second point that demands consideration is the origin of this vast amount of drift material.

The Laramie beds are regarded as accumulations in fresh water. The great fresh water lakes of the present do not seem to present conditions which, though operative for a long period of time, would give rise to similar deposits, for the amount of drift material that becomes waterlogged in them and sinks to the bottom far from the shore where it could accumulate without addition of silt, is probably small. Strong currents and winds either carry most of the drift wood out of the lake or crowd it to shore where it is buried in sand. In the smaller lakes of northern Michigan and Minnesota, located in the heart of the timber country, conditions are different. Vegetation is abundant to the water's edge and sand beaches are rare. Any one who has seen certain of them during logging time can readily believe that, if by natural conditions logs were poured into the lakes as they are yearly during the logging season and became waterlogged there, woody beds equal to those of the Laramie lignites would result. Perfectly natural conditions as they exist to-day, operating through a very long period of time, would doubtless contribute to one of these lakes enough material for a lignite bed, but as the time in which the accumulation takes place is increased, the probability of a large admixture of foreign matter is increased. It is true that the forest conditions that exist around these lakes prevent the carrying in of large quantities of sand and dust by wind, but tributary streams that are active enough to bring down considerable quantities of timber would contribute to the lake a good

deal of silt as well. This would be deposited near the mouths of the streams for the most part. It is conceivable that many logs would drift beyond the zone of heavy silt deposit, and that a woody deposit highly mixed with silt near the stream delta, and growing purer with distance or other conditions that diminished current action, might arise. Nevertheless. it is plain that if conditions which would hasten the accumulation of woody matter may be assumed, the problem will be simplified.

The Rocky mountain uplift is generally credited to the Laramie, for Laramie strata are found well upon the mountain slopes. No evidence is at hand, however, to show that the late Laramie ever wholly covered the Rocky mountain area. If the uplift occurred all through the Laramie, the explanation that has been offered for the lignites receives material aid. The uplift, it may be conceived, began with the region that is now the heart of the Rockies, and continued till the region as far east as western Dakota was slightly affected. The effect of the earliest movement would be to quicken erosion in the region of uplift and increase deposition at its edge, in the central and eastern Montana country. Here the disturbance in the west would manifest itself in abnormal drainage conditions. Lakes would arise, fed by the streams coming from the west. Streams thus rapidly quickened in a forest country would carry much drift timber, for during the former period of relative inactivity forest conditions would have crept down close to the stream banks. Undercutting, with landslides, would throw into the valleys the giant redwoods, which the next flood would carry to the lakes. As the uplift continued and its axis widened, the region of deposition would be carried farther and farther east, and there would be a gradual shifting of the lake country in that direction. The Laramie strata to the west would be tilted and faulted as they are to-day, and those farther from the center of upward movement would lie practically horizontal.

Such an hypothesis seems to fit the nature of the Laramie clays and sandstones, as well as the peculiarities of

the interbedded lignite. The cross-bedded sandstone which passes gradually into clay; the clay beds that are sometimes remarkably persistent in color and texture, and at other times extremely variable, passing abruptly into carbonaceous clay and on into lignite; the large tree trunks that are scattered through all of the clay beds; all suggest the former presence of shifting lakes fed by streams laden with silt and timber. In one instance stumps three and four feet in diameter and fifteen feet high, silicified, were found over an extensive area standing upright. They were not associated with a lignite bed, and seem to represent part of a forest that was silted under by the shifting of a lake bed.

This view of the origin of the lignites is admittedly hypothetical. It seems, however, to present a reasonable line for study, to form a working hypothesis, to use the admirable term of Professor Chamberlin. To prove or disprove it, additional study will be directed to the following points: To determine whether the Laramie of the mountains is older than that of the plains; to show whether in the main the wood from which the lignite was derived was of land growth and to determine the habitat of the species, and to see what light the fauna of the Laramie throws on the relation of land to water at that time.

THE SCROPHULARIACEÆ OF IOWA.

BY T. J. AND M. F. L. FITZPATRICK.

SCROPHULARIACEÆ *Lindley*, Nat. Syst. Ed. 2, p. 288. 1836.

FIGWORT FAMILY.

The Figwort family comprises nearly 2,500 species, which are grouped in about 165 genera. The species are quite widely distributed, but are most abundant in temperate regions, occurring rarely towards the poles and equator. Heller, in his Catalogue of North American Plants, includes 51 genera and 627 species and varieties belonging to the Figwort family. The flora of Iowa has representatives of 21 genera, there being about 45 species.

In general terms the Figwort family includes herbs, shrubs or trees (ours all herbs), with alternate or opposite exstipulate leaves, and perfect, usually complete, irregular and mostly 4—5-parted flowers. Leaves entire or variously modified. Corolla imbricated in the bud, 2-lipped or nearly regular. Stamens 2-5, inserted on the tube of the corolla, didynamous or equal, 1-3 of them usually rudimentary. Ovary free, 2-celled; style 1, stigma entire or 2-lobed. Fruit a 2-celled, many-seeded capsule.

The following key may be improvised for the genera represented in Iowa:

SUB-ORDER ANTIRRHINIDEÆ *Bentham*.

Upper lip of the corolla usually covering the lower.

Tribe VERBASCEÆ. Leaves alternate; flowers spicate or racemose; corolla rotate, its lobes subequal.

VERBASCUM. Stamens 5, all antheriferous.

Tribe ANTIRRHINEÆ. Leaves alternate or opposite; flowers racemose; corolla tubular, spurred below.

LINARIA. Corolla with a slender spur; stamens 4; capsule opening near the summit.

Tribe CHELONEÆ. Leaves opposite; flowers in cymose o· umbel-like clusters, often collectively paniculate; corolla tubular or irregular, 2-lipped, not saccate or spurred; stamens 4 and a rudimentary fifth.

SCROPHULARIA. Corolla small, globose, 4 of its lobes erect, the fifth reflexed, the fifth stamen a scale from the upper lip.

PENTSTEMON. Corolla tubular; fifth stamen as long as the others; seeds angular, wingless.

CHELONE. Calyx with three bracts at the base; corolla tubular inflated; fifth stamen shorter; seeds winged.

COLLINSIA. Corolla blue and white, 2-cleft, saccate above; fifth stamen gland-like.

Tribe GRATIOLEÆ. Leaves mostly opposite; flowers solitary, axillary; stamens with anthers 2—4; fifth stamen wanting.

MIMULUS. Leaves simple; calyx 5-angled, 5-toothed; corolla elongated; stamens 4.

MONNIERA. Leaves simple; calyx-segments unequal, the upper one largest; stamens 4.

CONOBEA. Leaves pinnately parted; calyx 5-parted; corolla short: stamens 4.

GRATIOLA. Leaves simple; stamens with anthers 2, the sterile short or wanting.

ILYSANTHES. Leaves simple; stamens with anthers 2, the sterile exserted.

SUBORDER RHINANTHIDEÆ *Bentham.*

Under lip or the lateral lobes covering the upper lip in the bud.

Tribe DIGITALEÆ. Leaves alternate, opposite, verticillate or basal; flowers racemose; calyx 4-parted; stamens 2—4; anthers 2 celled.

VERONICA. Leaves opposite; flowers solitary or racemose; corolla rotate, nearly regular; stamens 2; capsule obcordate or emarginate, compressed.

LEPTANDRA. Leaves verticillate, rarely opposite; flowers in spike-like racemes; capsule ovoid, not compressed.

WULFENIA. Leaves alternate and basal; corolla campanulate, 2—4-lobed, irregular; stamens 2-4.

Tribe GERARDIEÆ. Leaves opposite or the upper alternate; stamens 4, in pairs; anthers 2-celled.

DASYSTOMA. Stamens didynamous, included; corolla yellow; anthers awned at the base.

GERARDIA. Stamens didynamous, included; corolla pink or purple, rarely white; anthers awnless.

AFZELIA. Stamens nearly equal, scarcely if at all exserted.

Tribe EUPHRASIEÆ. Leaves alternate or opposite; flowers racemose or spicate; corolla tubular, 2-lipped, upper lip arched or curved; stamens didynamous.

CASTILLEJA. Leaves alternate; anther cells unequal, separate; capsule many-seeded.

PEDICULARIS. Leaves alternate or opposite; anther-cells equal, not separate; capsule many-seeded.

MELAMPYRUM. Leaves opposite; anther cells equal; capsules 1—4-seeded.

VERBASCUM *L.* Sp. Pl. 177. 1753.

Biennials, with alternate leaves, and ephemeral racemose or spicate flowers, calyx 5-parted, corolla rotate, with five subequal lobes. Stamens 5, all perfect; three or five of the filaments bearded. Represented in Iowa by the following two species:

VERBASCUM THAPSUS *L.* Sp. Pl. 177. 1753.

Growing 2-5 feet high, woolly throughout, rarely branched; leaves entire, oblong-ovate, decurrent; flowers in a dense spike, yellow; the three upper stamens shorter and bearded.

This species is a native of Europe and Asia, and is with us only as an emigrant, having spread from Nova Scotia to Florida, west to Minnesota and Kansas. It is found in old fields, pastures, by the way-side, and in waste places, preferring dry soil. The plants begin to bloom in July and continue until the close of September. The spikes elongate as the flowers open in succession upwards. The species is considered as a weed and is inclined to become troublesome in pastures. Type locality: "Habitat in Europæ glareosis sterilibus."

The species is common throughout the state. Specimens in our collection are from Johnson, Van Buren, Appanoose, Decatur, Ringgold, Taylor, and Pottawattamie counties. We have observed the species in Winneshiek, Allamakee, Clayton, Dubuque, Jackson, Scott, Des Moines, Wapello, Clark, Page, Fremont, and Montgomery counties. Prof. Bessey reported the species from Scott county; Prof. Fink from Fayette county; Mr. Gow from Adair county; Messrs. Barnes, Reppert, and Miller from Muscatine county; Prof. Shimek from Lyon county, and Mr. Mills by note from Henry county. The State University herbarium has specimens from the additional counties of Jones, Calhoun, and Chickasaw.

Parry, Owen's Report Geol. Surv. Wisc., Ia., and Minn., p. 616; Arthur, Contr. Fl., Ia., p. 22; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 510; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Pammel, *Proc. Iowa Acad.* Sciences, Vol. 4, p. 117; Bessey, Fourth Bien. Rep. Agr.

Col., p. 111; Halsted, Bull. Iowa State Agr. Col., Feb., 1888, p. 43 and p. 106; B ll., Nov., 1886, p. 51; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 123 and p. 156; Vol. 6, p. 191; Manual Fl. Plants of Iowa, p. 121; Gow, Proc. Iowa Acad. Sciences, Vol. 8, p. 157; Rigg, Notes on the Flora of Calhoun county, p. 22; Shimek, Iowa Geol. Sur., Vol. 10, p. 219; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 242.

VERBASCUM BLATTARIA *L.* Sp. Pl. 178. 1753. Moth Mullein.

Verbascum claytoni Michx. Fl. Bor. Am. 1:148. 1803.

Stem 2—4 feet high, simple or branched, smoothish; leaves oblong, ovate or lanceolate, clasping, coarsely dentate, lower leaves often lyrate, petioled, doubly serrate, laciniate or pinnatifid; flowers in a loose raceme, yellow or white with a purplish tinge; stamens bearded with violet hairs.

This species is found in dry soil, blooming from July until late September. It is a native of Asia and Europe and naturalized in America, ranging from Canada to Florida, west to Minnesota and Kansas. In Iowa the species is infrequent and seems to spread very slowly, and is found in waste places. Type locality: "Habitat in Europæ australioris locis argillaceis."

Our specimens are from Johnson county. We have observed the species in Van Buren county. Professor Hitchcock reported the species from Story county; Professor Pammel from Muscatine county; and Mr. Mills, by note, from Henry county.

Arthur, Contr. Fl. Ia., p. 22; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 510; Pammel, Proc. Iowa Acad. Sciences, Vol. 1, Pt. 2, p. 92; Vol. 4, p. 117; Shimek, Bull. Lab. Nat. Hist., S. U. I., Vol. 3, p. 207; Halsted, Bull. State Agr. Col., Feb. 1888, p. 43; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 156; Manual Fl. Plants of Iowa, p. 121; Barnes, Reppert, and Miller, Proc. Davenport Acad. Sciences, Vol. 8, p. 242.

LINARIA *Juss.* Gen. Pl. 120. 1789.

Herbs with alternate or sometimes opposite entire dentate or lobed leaves, and yellow, white, blue or variegated flowers. Calyx 5-parted. Corolla spurred at the base, 2-lipped, upper lip 2-lobed, lower 3-lobed; throat almost

closed by a prominent palate. Stamens 4. Style slender; stigma scarcely lobed. Capsule thin, many-seeded, opening irregularly near the summit.

LINARIA LINARIA (*L.*) *Karst.* Butter and Eggs.

Antirrhinum linaria L. Sp. Pl. 616. 1753.
Linaria vulgaris Mill. Gard. Dict. Ed. 8, No. 1. 1768.
Linaria linaria Karst. Deutsch. Fl. 947. 1880-83.

Perennial; stem 1—3 feet height, glabrous; leaves alternate, linear, entire, sessile; flowers yellow, in a dense raceme; spur long, slender; seeds winged.

A species native of Europe and Asia and naturalized in America, ranging from Nova Scotia to Virginia, west to Manitoba and Nebraska. With us the species occurs by the wayside and in waste places near gardens or old building sites, blooming from July until September, and is infrequent throughout the state. Type locality: "Habitat in Europæ ruderatis."

Specimens in our collection are from Winneshiek, Clayton, Johnson, Van Buren, Decatur, and Page counties. We have observed the species in Des Moines, Wapello, Appanoose, and Clark counties. The State University herbarium has specimens from Louisa, Henry, Lee, Webster, and Story counties. Professor Bessey reported the species from Warren, Polk, and Floyd counties; Professor Fink from Fayette county; Messrs. Barnes, Reppert, and Miller from Scott and Muscatine counties; and Mr. J. P. Anderson, by note, from Lucas county.

Arthur, Contr. Fl. Ia., p. 22; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Pammel, Proc. Iowa Acad. Sciences, Vol. 4, p. 117; Bessey, Fourth Bien. Rep. Agr. Col., p. 111; Halsted, Bull. State Agr. Col., Feb., 1888, p. 43; Bull., Nov., 1886, p. 50; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124, p. 156; Vol. 6, p. 191; Manual Fl. Plants of Iowa, p. 121; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

LINARIA CANADENSIS (*L.*) *Dumort.*

Antirrhinum canadense L. Sp. Pl. 618. 1753.
Linaria canadensis Dumort, Bot. Cult. 2:96. 1802.
Linaria texana Scheele, Linn. 21:761.

Annual or biennial; leaves linear or linear-oblong, alternate or those of the sterile shoots opposite; flowers blue and white, in a long, slender raceme; spur filiform, curved.

A species of which Linnaeus gave the type locality as: "Habitat in Virginia, Canada," and which ranges from Nova Scotia to Florida and Alabama, west to Minnesota, Oregon, California, south to Texas, Central America, and South America. Although Iowa is well within the range of the species, yet it is scarcely known as belonging to our flora. The only references in Iowa literature concerning this species known to us are Prof. Arthur's, in his contributions, No. 3, who reported the species from Cedar Rapids and Vinton, Linn and Benton counties; a note in Bulletin of the Torrey Botanical Club, and the citation in our Manual.

Arthur, Proc. Davenport Acad. Nat. Sciences, Vol 2, p. 259; Fitzpatrick, Manual Fl. Pl. Iowa, p. 121; Bull. Torr. Bot. Club, Vol. 6, p. 209.

SCROPHULARIA *L.* Sp. Pl. 619. 1753.

Coarse perennials, with opposite leaves, and small, greenish purple cymose flowers. Calyx 5-parted. Corolla short, 5-lobed, four lobes erect, the fifth reflexed; tube globose. Stamens included, 4, and a rudimentary fifth on the upper side of the throat of the corolla.

SCROPHULARIA MARYLANDICA *L.* Sp. Pl. 619. 1753.

Scrophularia lanceolata Pursh, Fl. N. A., 2:419. 1814.

Scrophularia nodosa var. *Marylandica* A. Gray, Syn. Fl. 2: Part 1, 258. 1878.

Stem 3—7 feet high, 4-angled, with grooved sides, glabrous, branching; leaves large, ovate or ovate-lanceolate, thin, acuminate, sharply serrate; cymes in a slender terminal thyrse-like panicle; corolla brownish, purple within, throat but little contracted, the two lateral lobes slightly spreading, the upper lip erect, its lobes short and rounded; sterile stamen deep purple.

A species ranging from New England and Quebec, Ontario, west to Minnesota, Nebraska, and Oregon, south to Florida, Alabama, Louisiana, Arkansas, and Colorado, the

type locality being Virginia. With us the species occurs in rich, moist woods, flowering from July until September.

Specimens in our herbarium are from Winneshiek, Dubuque, Johnson, Jefferson, Des Moines, Decatur, and Ringgold counties. We have observed the species in Allamakee, Clayton, Van Buren, and Taylor counties. The State University herbarium has specimens from Jones, Floyd, Lee, Cerro Gordo, and Lyon counties. Professor Bessey reported the species from Story county; Professor Fink from Fayette county; Professor Pammel from Woodbury county; Messrs. Nagel and Haupt from Scott county; Messrs. Barnes, Reppert, and Miller from Muscatine county; and Mr. Mills from Henry county.

Parry, Owen's Report Geol. Sur. Wis., Ia., & Minn., p. 616; Arthur, Contr. Fl. Ia., p. 22; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Hitchcock, Trans. St. Louis Acad. Nat. Science, Vol. 5, p. 511; Pammel, Proc. Iowa Acad. Sciences, Vol. 3, p. 127; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 111; Halsted, Bull. Iowa State Agr. Col., Feb., 1888, p. 43; Bull. Nov., 1886, p. 51; Shimek, Proc. Iowa Acad. Sciences, Vol. 5, p. 31: Iowa Geol. Sur., Vol. 10, p. 177; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124 & p. 156; Vol. 6, p. 192; Manual Fl. Plants of Iowa, p. 122; Barnes, Reppert, and Miller, Proc. Davenport Acad. Sciences, Vol. 8, p. 243.

SCROPHULARIA LEPORELLA *Bicknell*, Bull. Torr. Club, 23:317. 1896.

Stem 3—6 feet high; puberulent below, sharply 4-angled with flat sides, simple or occasionally branched; leaves ovate to lanceolate, acuminate, short-petioled, usually incised-dentate; flowers in elongated thyrses; corolla contracted at the throat, green to purple, shining without, dull within, the two lateral lobes erect; lobes of the upper lip sometimes narrowly oblong; sterile stamen greenish yellow.

A species for a long time confounded with *Scrophularia marylandica*. The range of the species as now known is from Connecticut to Virginia, west to Minnesota and Nebraska. The species is said to bloom from May until July and is out of bloom by the time the flowers of

Scrophularia marylandica commence opening. On June 2, 1901, we found a large number of specimens of *Scrophularia leporella* in Johnson county in low woods near the Iowa river. This species occupied the woods to the exclusion of *Scrophularia marylandica*, in fact, as Mr. Bicknell notes, the species, unless by accident, never seem to be associated. Type locality: "Common near New York City."

PENTSTEMON *Solander* in Aiton Hort. Kew. 3:511. 1789.

Perennials, with simple stems or stems branched from the base. Leaves opposite, the upper sessile, the lower petioled. Flowers thyrsoid or racemose-panicled, showy. Calyx 5-parted. Corolla, tubular, often inflated, campanulate, usually 2-lipped, the upper lip 2-lobed, the lower 3-lobed. Stamens 5, four antheriferous, declined below, ascending above, the fifth sterile. Capsule ovoid-conical, with many angular seeds.

Stem pubescent or puberulent nearly or quite to the base. *P. hirsutus.*
Only the inflorescence or calyx or pedicels pubescent.
  Stem leaves ovate, oblong or lanceolate. *P. digitalis.*
  Stem leaves linear-lanceolate. *P. gracilis.*
Whole plant glabrous and somewhat glaucous. *P. grandiflorus.*

PENTSTEMON HIRSUTUS (*L.*) *Willd.*

Chelone hirsuta L. Sp. Pl. 611. 1753.
Pentstemon pubescens Solan. in Aiton Hort. Kew. 3:360. 1789.
Pentstemon hirsutus Willd. Sp. Pl. 3:227. 1801.

Stem 1—3 feet high, downy-pubescent; leaves oblong to lanceolate, denticulate or entire, radical leaves ovate or oblong; flowers in a narrow panicle; corolla pale-purple, gradually dilated, throat nearly closed by two bearded folds from the lower lip; sterile filament bearded.

A species ranging from Maine to Florida, west to Ontario, Manitoba, Minnesota and Texas. The species occurs in dry woods on hills and bluffs, the flowers opening mostly in June, but often in May and July. In some localities the species is frequent, but generally in the state it is rather uncommon. Type locality: "Hab. in Virginia."

Specimens in our collection are from Muscatine, Appanoose, Decatur, and Lyon counties. The State University herbarium has specimens from Henry county and northern Iowa. Prof. Bessey reported the species from Des Moines county and Dr. Parry and Messrs. Nagel and Haupt from Scott county.

Parry, Owen's Report Geol. Sur Wis. Ia. and Minn., p. 616. Arthur, Contr. Fl. Ia., p. 22; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; MacMillan, Met. Minn. Valley, p. 462; Gray, Synop. Fl. Vol. 2, Pt. 1, p. 288; Bessey, Fourth Bien. Rep. Agr. Col., p. 111; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 156; Manual Fl. Plants of Iowa, p. 122; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243; Mohr, Plant Life of Alabama, p. 718; Gray, Synop. Fl., Vol. 2, Pt. 1, p. 268.

PENTSTEMON DIGITALIS (*Sweet.*) *Nutt.*

Chelone digitalis Sweet, Brit. Fl. Gard. 2, *Pl. 120*. 1820–27.
Pentstemon digitalis Nutt. Trans. Am. Phil. Soc. (II) 5: 181. 1833–37.
Pentstemon lævigatus var. *digitalis* A. Gray, Syn. Fl. 2: Part 1, p. 268. 1878.
Pentstemon lævigatum, authors.

Stem 2—5 feet high, glabrous; leaves ovate-lanceolate, usually serrulate; the basal oval or oblong; corolla white, inflated, campanulate, throat open, beardless; sterile filament thinly bearded.

This species ranges from Maine and New York to Virginia, west to Iowa and Arkansas. The species occurs along borders and in woods and thickets, the flowers opening usually in June, but found in the latter part of May and in July, and is rather frequent in eastern Iowa. Nuttall's type locality is: "Arkansas Territory, in wet woods and prairies; common."

Specimens in our herbarium are from Johnson and Appanoose counties. Specimens in the State University herbarium from Louisa, Lee, and Lyon counties are referred here. Messrs. Barnes, Reppert, and Miller reported the species from Scott and Muscatine counties.

Parry, Owen's Report Geol. Sur. Wis., Ia. & Minn., p. 616; Arthur, Contr. Fl. Ia., p. 22; Shimek, Proc. Iowa Acad. Sciences, Vol. 5, p. 31; Iowa Geol. Sur., Vol. 10, p. 171; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 156; Manual Fl. Plants of Iowa, p. 122; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

PENTSTEMON GRACILIS *Nutt.* Gen. 2:52. 1818.

Stem 6—18 inches high, glabrous or nearly so below; basal and lower leaves linear-oblong or spatulate, denticulate or entire, the upper linear-lanceolate, or lanceolate, denticulate; inflorescence glandular-pubescent; corolla purple.

The range of this species as given by Britton and Brown in their Illustrated Flora is Manitoba to Minnesota and Missouri, west to the Northwest Territory and Colorado. Nuttall gave the type locality as: "HAB. From the Arikarees to Fort Mandan, in depressed soils." The species occurs on moist prairies and blooms in May, June, and July. In Iowa the only county known where this species occurs is Lyon county, where it is said to be infrequent. It was first collected and reported by Professor Shimek.

Shimek, Proc. Iowa Acad. Sciences, Vol. 4, p. 74; Iowa Geol. Sur., Vol. 10, p. 173; Fitzpatrick, Manual Fl. Plants of Iowa, p. 122.

PENTSTEMON GRANDIFLORUS *Nuttall* in Fraser's Cat. 1813.

Pentstemon bradburi Pursh, Fl. Am. Sept. 2:738. 1814.

Stem 2—3 feet high, glabrous, glaucous; cauline leaves oblong or oval; thick, entire, clasping or perfoliate, the basal obovate; corolla large, campanulate, nearly regular, lavender-blue; sterile filament incurved at the apex, puberulent.

This species is found on prairies in Illinois, Iowa, Minnesota, South Dakota, and Kansas. The flowers appear in June, July, and August. Type locality: "Collected a considerable distance up the Missouri."

Specimens in our herbarium are from Muscatine, Fremont, and Lyon counties. Professor Bessey reported the species from Dubuque county and Professor Pammel from Woodbury county. The State University has specimens from Dubuque, Delaware, Louisa, Blackhawk, Pottawattamie, and Lyon counties.

Arthur, Contr. Fl. Ia, p. 22; Pammel, Proc. Iowa Acad. Sciences, Vol. 1, Pt. 2, p. 90; Vol. 3, p. 127; Shimek, Proc. Iowa Acad. Sciences, Vol. 4, p. 74; Bull. Lab. Nat. Hist., S. U. I., Vol. 3, p. 207; Iowa Geol. Sur.,

Vol. 10, p. 173; Bessey, Fourth Bien. Rep. Ia. Agr. Col., p. 111; Fitzpatrick, Proc. Ia. Acad. Sciences, Vol. 6, p. 192; Manual Fl. Plants of Iowa, p. 122; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

CHELONE *L.* Sp. Pl. 611. 1753.

Erect perennials, with angled stems, and opposite petioled leaves. Flowers axillary, nearly sessile, in clusters; calyx with three bracts, 5-parted, segments ovate or lanceolate. Carolla tubular, inflated, 2-lipped, much longer than the calyx; the upper lip arched, notched at the apex or entire, the lower lip 3-lobed, bearded in the throat. Stamens four, with woolly filaments and anthers, the fifth anther rudimentary. Seed with a membraneous wing.

CHELONE GLABRA *L.* Sp. Pl. 611. 1753.

Chelone glabra var. *alba* Pursh, Fl. Am. Sept. 2:427. 1814.

Stem slender, 1—5 feet high; leaves sessile or short-petioled, narrowly lanceolate, tapering both ways, appressed serrate; flowers clustered, white or roseate, bracts not ciliolate.

This species ranges from Newfoundland to Florida, west to Manitoba and Kansas. The species grows in swamps and wet places, blooming from July until late in September, and in Iowa it is rather infrequent and seems to be found only in the eastern portion. Type locality: "Hab. in Virginia, Canada."

Specimens in our collection are from Winneshiek and Johnson counties. The State University herbarium has specimens from Allamakee, Dubuque, and Muscatine counties. Prof. Fink reported the species from Fayette county.

Parry, Owen's Report Geol. Sur. Wis. Ia. and Minn., p. 616; Arthur, Contr. Fl. Ia., p. 22; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124 and p. 156; Manual Fl. Plants of Iowa, p. 122; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

CHELONE OBLIQUA *L.* Syst. Ed. 11, No. 4. 1767.

Chelone purpurea Mill. Dict. No. 2. 1768.
Chelone glabra var. *purpurea* Michx. Fl. Bor. Am. 2:24. 1803.
Chelone glabra var. *purpurea* Pursh, Fl. Am. Sept. 2:427. 1814.
Chelone glabra var. *lanceolata* Nutt Gen. 2:51. 1818.
Chelone latifolia Muhl. Cat. ex Elliott's Sk. Bot. S. C. and Ga. 2:127. 1824.

Stem slender, 1—4 feet high; leaves broadly lanceolate or oblong, incisely serrate; flowers rose-purple; bracts ciliolate.

This species ranges from Virginia to Iowa, south to Florida. It occurs in wet woods and thickets and in Iowa the flowers appear during the month of August, but occasionally may be found in July or September. The occurrence of the species within our limits is infrequent, and is to be found only in the eastern portion of the state.

Specimens in our herbarium are from Muscatine and Jefferson counties. The State University herbarium has a specimen from Des Moines county.

Shimek, Bull. Lab. Nat. Hist., S. U. I., Vol. 3, p. 198; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 156; Manual Fl. Plants of Iowa, p. 122; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

COLLINSIA *Nuttall*, Journ. Acad. Phil. 1:190. *pl.* 9. 1817.

Low delicate annuals or biennials, with opposite leaves, and axillary or terminal umbellate flowers. Calyx 5-cleft. Corolla 2-lipped, the upper lip 2-cleft, the lower lip 3-lobed; tube saccate. Stamens 4, and a rudimentary gland-like fifth.

COLLINSIA VERNA *Nutt.* Journ. Acad. Phil. 1:190. *pl. 9.* 1817

Stem 6—18 inches high, branched, glabrous or puberulent; leaves clasping, ovate or ovate-lanceolate; peduncles slender; whorls of 2-6 flowers; corolla blue and white, twice the length of the narrow calyx-teeth.

This species known as Blue-eyed Mary or Innocence ranges from New York to Wisconsin, Illinois, and Iowa, south to Pennsylvania, Kentucky, and Indian Territory.

The habitat is moist soil in woods and thickets, the time of blooming being April, May, and June. In Iowa the species is known to occur only in the southeastern portion. The specimens in our collection were collected, April 24, 1896, in Jefferson county, Iowa, near Fairfield. The species was frequent and apparently local. Professor Arthur has reported the species from Lee county.

Arthur, Proc. Davenport Acad. Nat. Sciences, Vol. 2, p. 126; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 4, p. 108; Vol. 5, p. 156; Manual Fl. Plants of Iowa, p. 123.

MIMULUS *L.* Sp. Pl. 634. 1753.

Stems 4-sided, prostrate or erect. Leaves simple, opposite. Flowers peduncled, axillary, solitary. Calyx 5-angled, 5-toothed, the upper tooth the largest. Corolla ringent, 2-lipped; the upper lip 2-lobed, the lower 3-lobed. Stamens 4. Stigma 2-lobed. Capsule many-seeded.

MIMULUS RINGENS *L.* Sp. Pl. 634. 1753.

Perennial; stem 1—3 feet high, glabrous; leaves lanceolate, sessile, acuminate, entire or serrate, base cordate clasping; peduncles longer than the calyx; calyx teeth nearly equal; corolla violet, sometimes white, throat closed by prominent folds.

This species ranges from Nova Scotia to Manitoba and Nebraska, south to Virginia, Tennessee, and Texas. Within our limits the species is common and occurs in damp soil along streams, ditches, swamps or boggy places. The flowers open from June until September. Type locality: "Habitat in Virginia, Canada."

Specimens in our collection are from Winneshiek, Allamakee, Clayton, Johnson, Decatur, Ringgold, and Kossuth counties. We have observed the species in Dubuque county. The State University herbarium has specimens from Jones, Louisa, Des Moines, Lee, Calhoun, Dallas, Dickinson, Story, and Lyon counties. Professor Bessey reported the species from Story and Poweshiek counties; Professor Pammel from Woodbury and Muscatine coun-

ties; Professor Fink from Fayette county; Messrs. Nagel and Haupt from Scott county; and Mr. Mills, by note, from Henry county.

Prof. Bessey, in commenting on the Poweshiek locality, says: "At the latter place Professor Parker describes it as having a stem four-angled; two opposite sides convex, the other two equally concave."

Arthur, Contr. Fl. Ia., p. 22; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Gray, Synop. Fl., Vol. 2, Pt. 1, p. 276; Pammel, Proc. Iowa Acad. Sciences, Vol. 3, p. 127; Plant World, Vol. 2, p. 183; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 111; Halsted. Bull. State Col. Agr., Feb., 1888, p. 108; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124, and p. 157; Vol. 6, p. 192; Manual Fl. Plants of Iowa, p. 123; Rigg, Notes on the Flora of Calhoun county, p. 22; Shimek, Iowa Geol. Sur., Vol. 10, p. 178; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

MIMULUS ALATUS *Solander* in Aiton Hort. Kew. 2:361. 1789.

Perennial, glabrous; stem narrowly winged at the angles; leaves ovate, ovate-lanceolate or oblong, acuminate, conspicuously serrate, margined-petioled; peduncle shorter than the calyx; corolla violet.

This species ranges from Iowa to Connecticut, south to Georgia, Alabama, and Texas. The species occurs within our limits only in southern Iowa, where it may be found in damp soil along wooded streams or bogs; blooming from June until September, and frequent in occurrence. Type locality: "Native of North America."

Specimens in our collection are from Appanoose and Decatur counties.

Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p 157; Vol. 6, p. 192; Manual Fl. Plants of Iowa, p. 123.

MIMULUS JAMESII *T. & G.;* Benth. in D. C. Prodr. 10:371. 1846.

Perennial by stolons; stem spreading, diffuse, rooting, smooth; leaves roundish, obscurely serrate, sessile or petioled, palmately veined, calyx ovate, oblique, upper tooth longest, inflated in fruit; corolla yellow, lower lip bearded, throat *open*.

Britton and Brown's Illustrated Flora gives the range of this species as Ontario to Nebraska and Mexico, west to Montana and Arizona. So far as known this species occurs in but two counties in Iowa, namely Winneshiek and Des Moines. Our specimens are from Winneshiek county, where the species was found in wet ravines and near or in calcareous springs. We also observed the species in Des Moines county below Burlington in the ravine leading to Indian spring. Dr. Parry in Owen's report says: "This peculiar northwestern species is only found floating on the pure issue of the coldest springs, which it mats with its succulent foliage, continuing to put forth its yellow blossoms through the entire flowering season."

Arthur, Contr. Fl. Iowa, p. 22; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124 and p. 157; Manual Fl. Plants of Iowa, p. 123.

MONNIERA *P. Br.* Civ. & Nat. Hist. Jam. 269, *pl.28, f. 3.* 1755.

[HERPESTIS Gaertn. Fruct. & Sem. 3:186, pl. 214. 1805.]

Ours a perennial by stolons, with opposite entire leaves, and small blue peduncled axillary flowers. Calyx 5-parted. Corolla 2-lipped; the upper lip 2-lobed, the lower lip 3-lobed. Stamens 4, didynamous, included. Capsule oblong, obtuse, many-seeded.

MONNIERA ROTUNDIFOLIA *Michx.* Fl. Bor. Am. 2:22. 1803.

Herpestis rotundifolia Pursh, Fl. Am. Sept. 418. 1814.

Stems creeping, spreading, simple or branched; villous-pubescent; leaves obovate to orbicular, palmately veined; flowers 1 or 2 in the axils of the leaves.

According to Britton and Brown's Illustrated Flora this species ranges from Illinois to Nebraska, south to Tennessee and Texas. The season of bloom is from June until September. Type locality: "HAB. in regione Illinoensi."

Messrs. Nagel and Haupt reported the species from Scott county; Messrs. Barnes, Reppert, and Miller from Muscatine county, giving the locality as a shallow pond *near Muscatine*; and Professor Shimek from in and around

the edges of pools in the vicinity of the quartzite exposures in Lyon county.

Arthur, Contr. Fl. of Iowa, p. 22; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243; Fitzpatrick, Manual of Flowering Plants of Iowa, p. 123; Halsted, Bull. State Agr. Col., Nov., 1886, pp. 43 & 44; Shimek, Iowa Geol. Sur., Vol. 10, p. 179.

CONOBEA *Aubl.* Pl. Guian. 2:639, *pl. 258.* 1775.

Ours an annual herb, with opposite pinnately parted leaves, and small greenish-white axillary mostly solitary flowers. Calyx 5-parted, the segments narrow, equal. Corolla irregular, tube cylindric, the limb 2-lipped; the upper lip 2-lobed, the lower lip 3-lobed. Stamens 4, didynamous, included. Capsule narrowly ovoid, glabrous, many-seeded.

CONOBEA MULTIFIDA (*Michx.*) *Benth.*

Capraria multifida Michx. Fl. Bor. Am. 2:22, *pl. 35.* 1803.
Conobea multifida Benth. in D. C. Prodr. 10:391. 1846.

Stem 4—8 inches high, at length diffusely branched, finely viscid-pubescent; leaves petioled, segments linear or linear-oblong, obtuse, entire or incised.

A species growing in sandy soil along streams and rivers and ranging from Ohio to Iowa and Kansas, south to Kentucky and Texas. The flowering season is from June until September. Type locality: "HAB. in ripis arenosis fluminum amniculorumque, in Tennassee et Illinoensi regioni."

Professor Arthur reported the species from Lee county; Professor Fink from Fayette county: and Messrs. Barnes, Reppert, and Miller from Scott and Muscatine counties.

Arthur, Proc. Davenport Acad. Nat. Sciences, Vol. 2, p. 126; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Manual Fl. Plants of Iowa, p. 123; Britton and Brown, Ills. Fl., Vol. 3, p. 159; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

GRATIOLA *L.* Sp. Pl. 17. 1753.

Low herbs, with opposite sessile leaves, and solitary axillary peduncled flowers. Calyx 2-bracted near the base, 5-parted, the divisions slender and nearly equal.

Corolla 2-lipped; the upper lip entire or 2-cleft, the lower 3-cleft. Stamens included, two being antheriferous and posterior, the anterior two being rudimentary and sterile or wanting. Capsule 2-celled, 4-valved, many-seeded. Our species are annuals.

GRATIOLA VIRGINIANA *L.* Sp. Pl. 17. 1753.

Gratiola officinalis Michx. Fl. N. A. 1:6. 1803. Not L.
Gratiola carolinensis Pers. Syn. 1:14. 1805.
Gratiola neglecta Torr. Cat. N. Y. Pl. 1819.
Gratiola missouriana Beck, Am. Jour. Sci., Ser. 1, 10:258. 1826.
Conobea borealis Spreng. Syst. 2:271. 1825.

Stem 4—7 inches high, much-branched, glandular-puberulent; leaves oblong or oblong-lanceolate, remotely toothed; peduncles slender, as long as the leaves; bracts leaf-like, equalling the calyx; flowers white or pale yellow; sterile filaments minute or wanting.

A species of wide distribution, ranging from Quebec, Ontario to British Columbia, south to Florida, Alabama, Texas, and California. The habitat is wet soil in fields and woods, the time of blooming being from May until the close of September. In Iowa the species is frequent but seemingly confined to the eastern and southern portions. Type locality: "Habitat in Virginia."

Specimens in our collection are from Winneshiek, Fayette, Appanoose, Wayne, Decatur, and Ringgold counties. The State University herbarium has specimens from Johnson and Henry counties. Messrs. Barnes, Reppert, and Miller reported the species from Scott and Muscatine counties.

Arthur, Contr. Fl. Ia., p. 22; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124, p. 157; Vol. 6, p. 192; Manual Fl. Plants of Iowa, p. 124; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

GRATIOLA SPHÆROCARPA *Ell.* Bot. S. C. and Ga. 1:14. 1816.

Gratiola accuminata Vahl, Enum. 1:92. Not Walt.
Gratiola virginica Pursh, Fl. Am. Sept. 1:12. 1814.
Gratiola carolinensis Le Conte in Ann. Lyc. N. Y. 1:105. 1824.

Stem 6—12 inches high, glabrous, ascending or erect, stout, simple or branched; leaves oblong or obovate-oblong, dentate or denticulate, 3—5-nerved, acute or obtusish at the apex, narrowed at the base; peduncles about the same length as the calyx, stout; calyx-lobes linear; corolla about twice the length of the calyx, its tube yellow, the limb paler; sterile filaments wanting; capsule globose, about three lines in diameter.

Dr. Mohr, in his Plant Life of Alabama, gives the range of this species as: "Coast of New Jersey, West Virginia, southern Illinois, southern Missouri and Arkansas, south to Florida and Texas." This range would place Iowa north of the supposed range of the species. In our herbarium is a series of specimens from Decatur county, Iowa, collected by J. P. Anderson, June 23, 1900. The plants are typical, being glabrous and having the very short stout peduncles, and large globose capsules. We also have two sheets from Virginius H. Chase, collected by him near Wady Petra in Stark county, north central Illinois, dated June 30, 1898, and June 22, 1899. This gives a considerable northward extension of the heretofore known range of the species. Wet soil and shallow water seems to be the usual habitat, and the species is said to bloom from June until September. We believe this to be the first report of the species from Iowa. Elliott gave the type locality as: "Grows in ponds four miles from Charleston, on the Neck."

ILYSANTHES *Raf.* Ann. Nat. 13. 1820.

Annuals, with opposite sessile leaves, and small purplish axillary flowers on slender naked pedicels. Calyx 5-parted, divisions nearly equal. Corolla 2-lipped; the upper lip erect, 2-lobed, the lower spreading and 3-cleft. Fertile stamens 2, their anther-sacs divergent; sterile stamens 2, forked, one division glandular. Stigma 2-lobed, capsule ovate or oblong, about equaling the calyx, many-seeded.

ILYSANTHES GRATIOLOIDES (*L.*) *Benth.*

Capraria gratioloides L. Sp. Pl. Ed. 2, 876. 1763.
Gratiola anagallidea Michx. Fl. Bor. Am. 1:6. 1803.
Gratiola dilatata Muhl. Cat. 1813.
Lindernia pyxidaria Pursh, Fl. Am. 2:419. 1814.
Herpestis callitrichoides HBK. N. Gen. et Spec. 1818.
Ilysanthes riparia Raf. Ann. Nat. 13. 1820.
Gratiola tetragona ? Ell. Sk. 1:16. 1821.
Gratiola attenuata Spreng. Syst. 1:39. 1825.

Stem 3—7 inches high, branched, spreading or erect; leaves ovate, ovate-oblong, or the lower obovate, obscurely toothed; corolla 3—5 lines long, hardly twice the length of the calyx.

This species ranges from New Brunswick to Florida and Alabama, west to Ontario, Minnesota and Texas. The habitat is wet soil on banks of streams, the time of blooming being from July until the close of September. In Iowa the species frequently occurs and is generally distributed. Linnæus gave the type locality as: "Habitat in Virginiæ aquosis."

Specimens in our herbarium are from Fayette, Johnson, Washington, Van Buren, Decatur, Ringgold, and Sioux counties. The State University herbarium has specimens from Chickasaw and Emmet counties. Professor Hitchcock reported the species from Story county; Professor Pammel from Woodbury and Muscatine counties; and Messrs. Barnes, Reppert, and Miller from Scott county.

Arthur, Contr. Fl. Ia., p. 22; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Pammel. Proc. Iowa Acad. Sciences, Vol. 3, p. 127; Plant World, Vol. 2, p. 184; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 157; Vol. 6, p. 192; Manual Fl. Plants of Iowa, p. 124; Shimek, Iowa Geo. Surv., Vol. 10, p. 178; Upham, Flora of Minn., p. 100; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243.

VERONICA *L.* Sp. Pl. 9. 1753.

Annual or perennial herbs, with opposite or alternate leaves, and solitary racemose or spicate flowers. Calyx usually 4-parted. Corolla rotate or salverform, usually 4-lobed, rarely 5-lobed; lower segments usually narrow.

Stamens two, exserted. Style slender; stigma capitate. Capsule flat or compressed, obtuse or obcordate, many-seeded.

* *Perennials; flowers in axillary racemes.*

Leaves ovate, oval, oblong or oblong-lanceolate; capsule compressed.

Stem leaves sessile, serrulate or entire. *V. anagallis aquatica.*

Leaves petioled, serrate. *V. americana.*

Leaves linear or linear-lanceolate; capsule flat. *V. scutellata.*

***Annuals; flowers solitary in the axils of the leaves.*

Plants erect, glabrous or glandular. *V. peregrina.*

Plants diffuse, pubescent. *V. arvensis.*

****Flowers in terminal spicate racemes. V. serpyllifolia.*

VERONICA ANAGALLIS-AQUATICA *L.* Sp. Pl. 12 1753.

Water Speedwell. Water Pimpernel.

Veronica anagallis L. of authors generally.

Stems fleshy, one foot high, smooth, erect or decumbent and rooting and the upper portion erect; leaves opposite, sessile, clasping, entire or serrulate; racemes from opposite axils; flowers small, corolla bluish; capsule orbicular, slightly notched.

This species ranges from Nova Scotia to British Columbia, south to eastern Virginia, Alabama, Nebraska, and New Mexico. Also said to be a native of Asia and Europe. Linnæus gave the type locality as: "Hab. in Europa ad fossas." In Iowa the species occurs in springs, pools, and brooks, and is rather frequent in eastern Iowa and extends westward across the state. Our specimens were collected during June and July, but the species blooms as early as May and as late as September.

Specimens in our collection are from Winneshiek, Allamakee, and Appanoose counties. The State University herbarium has specimens from Louisa, Johnson, Winnebago, Emmet, and Lyon counties. Prof. Bessey reported the species from Story county and Prof. Fink from Fayette county.

Arthur, Contr. Fl. Ia., p. 23; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Shimek, Bull. Lab. Nat. Hist.,

S. U. I., Vol. 4, p. 207; Iowa Geol Sur, Vol. 10, p. 179; Halsted, Bull. State Agr. Col., Nov., 1888, p. 51; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124, and p. 157; Manual Fl. Plants of Iowa, p. 124.

VERONICA AMERICANA *Schwein.;* Benth. in D. C. Prodr. 10:468. 1846. American Brooklime.

Veronica beccabunga Auc. Amer. Vet.
Veronica intermedia Schwein. Am. Journ. Sci. (I), 8:268. 1824.
Veronica anagallis Bong. Veg. Sitka. 1841.

This species is similar to *Veronica anagallis-aquatica,* but is stoloniferous and the leaves are petioled and serrate. Stems branched, decumbent, glabrous; leaves ovate, oblong, or oblong-lanceolate; the bases truncate, rounded or subcordate, the apex acutish or obtuse.

Britton and Brown's Illustrated Flora states that this species occurs in brooks and swamps and that the range is from Anticosta to Alaska, south to Pennsylvania, Nebraska, New Mexico, and California. We have specimens from Pennsylvania, Minnesota, and Wyoming. The species in all probability occurs in Iowa, but we have seen no specimens. Professor Arthur reported the species from Lee county, which is the only reference to Iowa save one we have noticed. His report was based on a specimen furnished by Dr. George E. Ehinger of Keokuk. Dr. Parry reported the species from Iowa but gave no locality. The time of blooming is given as being from April until September.

Arthur, Proc. Davenport Acad. Nat. Sciences, Vol. 2, p. 126; Fitzpatrick, Manual Fl. Plants of Iowa, p. 124; Parry, Owen's Report Geol. Sur. Wis., Ia. & Minn., p. 616.

VERONICA SCUTELLATA *L.* Sp. Pl. 12. 1753. Marsh Speedwell.

Stem 6—20 inches high, decumbent or ascending, usually rooting at the nodes below, glabrous or sparingly pubescent, perennial by leafy shoots or stolons; leaves linear or linear-lanceolate, sessile, slightly clasping, remotely denticulate; flowers blue, in axillary racemes; capsule very flat, broader than high, emarginate above, cordate below.

This species occurs in swamps, from Labrador to British Columbia, south to southern New York, Michigan, Minnesota, and California. It is also found in Europe and Asia. Messrs. Barnes, Reppert, and Miller in their Flora of Scott and Muscatine counties state that this species occurs in low wet ground at Noels, Scott county. This is the first and only report of its occurrence in the state and extends the range considerably southward. Type locality: "Habitat in Europæ inundatis."

Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 244.

VERONICA PEREGRINA *L.* Sp. Pl. 14. 1753. Purslane Speedwell. Neckweed.

Veronica marylandica Murr. Comm. Gott. 2:3. 1782 Not L.
Veronica caroliniana Walt. Fl. Car. 61. 1788.
Veronica xalipensis HBK. N. Gen. et Spec. 1818.

Stem 4—10 inches high, smoothish, ascending, branched; lower leaves petioled, oval-oblong, toothed, upper sessile, oblong-linear, entire; flowers short-pedicelled, solitary; corolla white, shorter than the calyx; capsule obcordate.

This species ranges from Nova Scotia to British Columbia, south to Florida, Alabama, Mexico, and California, generally speaking from the arctic circle to the gulf of Mexico; also in Central and South America, and distributed as a weed in the old world. Linnæus gave the type locality as: "Hab. in Europe hortis, arvisque." In Iowa the species is common in most places in woods by water courses or in cultivated soil where it grows as a weed. The flowers open all summer, from May until the close of September.

Specimens in our collection are from Johnson, Decatur, and Shelby counties. We have observed the species in Winneshiek county. The State University herbarium has specimens from Henry, Lee, and Dallas counties. Prof. Hitchcock reported the species from Story county; Prof. Fink from Fayette county; Messrs. Nagel and Haupt and

Dr. Parry from Scott county, and Messrs. Barnes, Reppert, and Miller from Muscatine county.

Parry, Owen's Rep. Wis. Ia. and Minn., p. 616; Arthur, Contr. Fl. Ia., p. 23; Proc Davenport Acad. Nat. Sciences, Vol. 1, p. 160; History of Floyd county, p. 308; Hitchcock, Trans. St. Louis Acad. Science, Vol 5, p. 511; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Burgess, Bull. Torr. Bot. Club, Vol. 6, p. 102; Halsted, Bull. State Agr. Col., Feb., 1888, p. 43; Bull. Nov., 1886; pp. 43, 44, and 48; Shimek, Proc. Iowa Acad. Sciences, Vol. 5, p. 31; Iowa Geol. Sur., Vol. 10, p. 183; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124, and p. 157; Manual Fl Plants of Iowa, p. 124; Barnes, Reppert, and Miller, Proc. Davenport Acad. Sciences; Vol 8, p. 244.

VERONICA ARVENSIS *L.* Sp. Pl. 13. 1753. Corn Speedwell.

Stem hairy, 3–9 inches high, single or diffusely branched, lower leaves petioled, ovate, crenate, the upper sessile, ovate or lanceolate, entire; flowers very small, axillary; capsule obovate, obcordate.

This species is a native of Europe and Asia, and occurs in America as a naturalized weed in fields, open woods, waste places, and grassy places in cultivated soil. The species ranges from Nova Scotia to Ontario and Minnesota, south to Florida, Alabama, Kansas, and Texas. In Iowa the species is frequent and blooms from May until September. Type locality: "Habitat in Europæ arvis cultis."

Specimens in our collection are from Muscatine and Henry counties. The State University has a specimen from Johnson county. Prof. Arthur and Prof. Upham reported the species from Winneshiek and Lee counties; Prof. Hitchcock from Story county, and Messrs. Nagel and Haupt from Scott county.

Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Arthur, Proc. Davenport Acad. Nat. Sciences, Vol. 4, p. 66; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Halsted, Bull. State Agr. Col., Feb., 1888, p. 43; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 157; Manual Fl. Plants of Iowa, p. 124; Upham, Flora of Minn., p. 100; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 244.

VERONICA SERPYLLIFOLIA *L.* Sp. Pl. 12. 1753. Thyme-leaved Speedwell.

Glabrous or puberulent; stems slender, decumbent, the branches 2—10 inches high, erect; leaves opposite, petioled, or the uppermost sessile, ovate, oval, or oblong, entire or crenulate; flowers in short spicate racemes, corolla pale blue or whitish; capsule broader than long, notched at the summit.

This species ranges from Labrador to Alaska, south to Georgia, Alabama, New Mexico, and California, occurring in fields and thickets, and blooming from April until August. The species also occurs in Europe, Asia, northern Africa, and South America. Linnæus gave the type locality as: "In Europa et America Septentrionali ad vias, agros." While Iowa is well located to have this species in its flora yet it has been reported but once, which report was made by Professor Arthur, who gave the locality, Johnson county.

Arthur, Proc. Davenport Acad. Nat. Sciences, Vol. 4, p. 66. Fitzpatrick, Manual of the Flowering Plants of Iowa, p. 125.

LEPTANDRA *Nuttall*, Gen. N. A. 1:7. 1818.

Ours an erect perennial herb, with opposite or verticillate leaves, and small minutely bracted white or blue flowers in dense peduncled spike-like racemes. Calyx 4-parted, short. Corolla tubular, nearly regular, 4-lobed, the tube cylindric, longer than the lobes. Stamens 2, exserted, inserted low down in the corolla tube. Capsule ovoid, not compressed, many-seeded.

LEPTANDRA VIRGINICA (*L.*) *Nutt.* Culver's-root.

Veronica virginica L. Sp. Pl. 9. 1753.
Veronica sibirica L. Sp. Pl. Ed. 2. 1:12. 1762.
Leptandra virginica Nutt Gen. 1:7. 1818.
Leptandra purpurea Raf. Med. Bot. 59. 1830.

Stem 2—6 feet high, smooth or somewhat downy; leaves opposite or 3—6 in a whorl, lanceolate, short-peti-

oled, pointed, serrate; flowers in terminal panicled spikes; parts sometimes in fives; corolla small, white or bluish; stamens and style much exserted; capsule, oblong, obtuse.

This species is found in moist soil in woods, thickets or meadows, and ranges from Nova Scotia to British Columbia, south to Alabama, Missouri, Nebraska, and Arkansas. The flowering season is from June until September. This species has received considerable attention in medical practice and in domestic arts. Various popular names have been given it, of which Culver's-root, Culver's Physic, Tall Speedwell, and Blackroot are the most common. The root is horizontal, irregular, and woody, about half an inch in thickness, 6—12 inches long, brownish internally, blackish externally, the dark rootlets being long and slender and issue horizontally. The root is the officinal portion of the plant and is gathered in the fall of the year. The properties are extracted in water heated to 212 degrees or in alcohol. Linnæus gave the type locality as: "Habitat in Virginia."

Specimens in our collection show considerable variation in certain characters of the leaves. Small forms often have the whorls of three leaves and one specimen has the leaves opposite. Whorls of four and six leaves are frequent, but whorls of five leaves are the most common. The number of leaves in a whorl usually remain constant in the same specimen, but one of our specimens has the lower whorls of six leaves and the upper of four. Doubtless there are other combinations. The leaves may be narrowly lanceolate, rather long acuminate and finely serrate or ovate-lanceolate to nearly ovate, short-acuminate and coarsely serrate or even a mixture of these characters. Occasionally a forked spike may be found. On the variation of this species Pursh says: "On the mountains of Virginia I observed a tall-growing variety, with purple flowers, extremely beautiful." This was described and figured by Rafinesque as a distinct species under the name of *Leptandra purpurea*. In Iowa the species is common and widely distributed.

Specimens in our herbarium are from Clayton, Dubuque, Muscatine, Johnson, Jefferson, Van Buren, Appanoose, Ringgold, Taylor and Sioux counties. We have observed the species in Winneshiek, Allamakee, Decatur, and Ringgold counties. The State University herbarium has specimens from Jones, Louisa, Henry, Lee, Story, Chickasaw, Calhoun, Cerro Gordo, Fremont, and Emmet counties. Professor Bessey reported the species from Poweshiek and Floyd counties; Professor Pammel from Woodbury and Lyon counties; Messrs. Nagel and Haupt from Scott county; Professor Fink from Fayette county; and Mr. Gow from Adair county.

Arthur, Contr Fl. Ia., p. 23; Bull Iowa Agr. Col., Nov., 1888, p 161; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Pammel, Proc. Iowa Acad. Sciences, Vol. 3, p. 127; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Halsted, Bull. State Agr. Col., Feb., 1888, p. 43; Bull. Nov., 1886, p. 51; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124 & p. 157; Vol. 6, p. 192; Manual Fl. Plants of Iowa, p. 125; Gow, Proc. Iowa Acad. Sciences, Vol. 8, p. 157; Rigg, Notes on the Flora of Calhoun County, p. 22; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 244.

WULFENIA *Jacq.* Misc. 2:60. *pl. 8.* 1781.

[SYNTHYRUS Benth. in D. C. Prodr. 10:454. 1846.]

Ours a pubescent perennial herb, with ovate or orbicular petioled basal leaves, sessile bract-like alternate cauline leaves, and greenish yellow flowers in a terminal bracteate spike. Calyx 4—5-parted; bracts oblong or linear. Corolla usually 2-lobed, sometimes 3—4-lobed. Stamens usually 2, sometimes 4. Ovary 2—3-celled; style slender, stigma capitate. Capsule compressed, emarginate, many-seeded.

WULFENIA HOUGHTONIANA (*Benth.*) *Greene.*

Synthyrus houghtoniana Benth. in D. C. Prodr. 10:454. 1846.
Wulfenia houghtoniana Greene, Erythea, 2:83. 1894.

Stem 1—2 feet high; basal leaves truncate or cordate at the base, crenulate, 5—7-nerved; cauline leaves small, somewhat clasping, crenulate.

This species is found in Indiana, Illinois, Michigan, Minnesota, Iowa, and Missouri. It occurs on dry prairies and in open woods, blooming during the months of May, June, and July. Dr. Parry in Owen's Report writes concerning this species: "Abundant on the high table-land overlooking the town of Stillwater, St. Croix. This northwestern plant, so unique in its botanical features, is no less interesting in its association with the name of the lamented Houghton."

Our Iowa specimen was collected in Muscatine county by Ferd. Reppert, June, 1897. Mr. Reppert reports that the species is not rare in the sandy open woods in the Cedar river region. Prof. Fink on the basis of a specimen in Dr. Parker's collection reports the species as rare on prairies in Fayette county. Messrs. Nagel and Haupt mention the species in their list of the Phænogamous plants collected in the vicinity of Davenport. Messrs. Barnes, Reppert, and Miller do not mention Davenport or Scott county in their flora as a locality for this species.

Arthur. Contr. Fl. Ia., p. 22; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 243; Fitzpatrick, Manual Flowering Plants of Iowa, p 125; Britton and Brown, Ills. Flora, Vol 3, p. 166; Gray's Manual, Ed. 6, p. 386; Bull. Torr. Bot. Club, Vol. 6, p. 209.

DASYSTOMA *Raf.* Journ. Phys. 89:99. 1819.

Erect annual or perennial herbs, partly parasitic on the roots of other plants, with opposite or alternate entire incised or pinnatifid leaves, and large showy yellow flowers, in terminal mostly leafy-bracted racemes or panicles. Calyx campanulate, 5-lobed. Corolla funnelform or campanulate-funnelform, the tube woolly or pubescent within, the limb 5-lobed. Stamens 4, didynamous, included, villous or pubescent; anthers similar, their sacs separate, awned at the base. Capsule oblong, acute, many-seeded.

Plants glabrous, cinerous or puberulent; corollas glabrous without.
- Cinerous-puberulent.
  - Leaves thin, all pinnatifid. *D. grandiflora*.
  - Leaves thickish, entire, dentate or the lower pinnatifid. *D. flava*.

Glabrous or nearly so throughout.
Leaves all except the uppermost pinnatifid. *D. virginica.*
Plants glandular-pubescent; corolla pubescent without. *D. pedicularia.*

DASYSTOMA GRANDIFLORA (*Benth.*) *Wood.* Western False Foxglove.

Gerardia grandiflora Benth. Comp. Bot. Mag. 1:206. 1835.
Dasystoma drummondii Benth. in D. C. Prodr. 10:520. 1846.
Dasystoma grandiflora Wood, Bot. & Flor. 231. 1873.

Stem minutely downy, 2—4 feet high, branched; leaves thin, short-petioled, ovate-lanceolate, incisely cut or pinnatifid, the upper leaves small, sessile; peduncles about the length of the calyx; corolla about 2 inches long, yellow, glabrous without.

This species occurs in dry open woods and thickets, blooming in July and August, and ranging from Wisconsin and Minnesota to Tennessee and Texas. In Iowa this species is found only in the eastern half of the state and is rather infrequent.

Specimens in our collection are from Muscatine, Johnson, Washington, Jefferson, Van Buren, and Appanoose counties. The State University herbarium has a specimen from Henry county. Messrs. Barnes, Reppert, and Miller have reported the species from Scott county.

Arthur, Contr. Fl. Ia., p. 23; MacMillan, Met. Minn. Valley, p. 468; Gray, Synop. Fl., Vol. 2, Pt. 1. p. 291; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 157; Manual Fl. Plants of Iowa, p. 125; Barnes, Reppert, and Miller, Proc. Davenport Acad. Sciences, Vol. 8, p. 244.

DASYSTOMA FLAVA (*L.*) *Wood.* Downy False Foxglove.

Gerardia flava L. Sp. Pl. 610. 1753.
Dasystoma pubescens Benth. in D. C. Prodr. 10:520. 1846.
Dasystoma flava Wood, Bot. & Fl. 230. 1873.

Downy grayish; stem 2—4 feet high, usually simple; leaves lanceolate, ovate-lanceolate, or oblong, entire or the leaves sinuate toothed or pinnatifid, short-petioled or the upper sessile.

This species occurs in dry woods and thickets and ranges from Massachusetts to Ontario and Wisconsin, south to

Georgia, Alabama, and Mississippi, blooming in July and August. Type locality: "Habitat in Virginia, Canada."

We have seen no Iowa specimens of this species. Prof. Arthur reported the species from Clinton county. Specimens in the State University herbarium from Jones, Johnson, and Henry counties have been referred to this species.

Arthur, Proc. Davenport Acad. Nat. Sciences, Vol. 4, p. 170; Fitzpatrick, Manual Fl. Plants of Iowa, p. 125.

DASYSTOMA VIRGINICA (*L.*) *Britton.*

Rhinanthus virginicus L. Sp. Pl. 603. 1753.
Gerardia flava L in Herb.
Gerardia quercifolia Pursh, Fl. Am. Sept. 423, Pl. 19. 1814.
Gerardia glauca Spreng. Syst. 2:807. 1825.
Dasystoma quercifola Benth. in D. C. Prodr. 10:520. 1846.
Dasystoma virginica Britton, Mem. Torr. Club, 5:295. 1894.

Stem 3—6 feet high, glabrous, glaucous, usually branched, stout; leaves ovate or ovate-lanceolate in outline, petioled, the lower 1—2-pinnatifid, 4—6 inches long, the upper incised or pinnatifid, the lobes oblong or lanceolate, acute, entire or dentate; calyx lobes ovate or ovate-lanceolate, acute, entire; capsule glabrous, twice the length of the calyx.

This species ranges from Maine to Michigan, and Minnesota, south to Florida, Alabama, Louisiana, Arkansas, and Missouri. The species grows in dry or moist woods, blooming in July, August, and September. The type locality is: "Habitat in Virginia."

We have seen no Iowa specimens of this species. Prof. Bessey reported the species from Burlington, Des Moines county. The species may reasonably be looked for in the region near the Mississippi river.

Bessey, Fourth Bien. Rep. Agr. Col., p. 112

DASYSTOMA PEDICULARIA (*L.*) *Benth.*

Gerardia pedicularia L. Sp. Pl. 611. 1753.
Dasystoma pedicularia Benth. in D. C. Prodr. 10:521. 1846.

Annual or biennial; stem 1—4 feet high, glandular-pubescent; viscid, much branched; leaves many, sessile or

the lower petioled, ovate or ovate-lanceolate in outline, 1—2-pinnatifid, the segments incised or crenate-dentate; pedicels ascending, usually longer than the calyx; calyx-lobes oblong, foliaceous; usually incised or pinnatifid; capsule 5—6 lines long, pubescent, with a flattened beak.

This species ranges from Maine to Ontario and Minnesota, south to Florida and Missouri, growing in dry woods and thickets and blooming during August and September. Type locality as given by Linnæus being: "Habitat in Virginia, Canada."

We have not seen any specimens from Iowa. The species may be expected to occur near the Mississippi river, and doubtless does, as it is found in Minnesota and Missouri. Dr. Parry reported that it occurred on dry prairies in Iowa. His locality probably being Davenport, Scott county.

Parry, Owen's Rep. Geol. Sur. Wis. Ia. and Minn., p. 616.

GERARDIA *L.* Sp. Pl. 610. 1753.

Annual or perennial, erect or branching herbs, with opposite or alternate leaves and showy racemose paniculate or solitary and axillary rose purple or whitish flowers. Calyx campanulate, 5-toothed or 5-lobed. Corolla tubular, varying to campanulate or funnelform, limb 5-lobed, the 2 upper lobes usually smaller and somewhat united. Stamens 4, didynamous, included. Style slender, thickened at the apex. Capsule globose or ovoid, pointed, many-seeded. Ours annuals.

* *Anthers nearly awnless; flowers pedicelled, purple or pink.*

Pedicels shorter or scarcely longer than the calyx and capsule.

Leaves very scabrous, filiform; capsule oblong. *G. aspera.*

Leaves slightly scabrous, linear; capsule globose. *G. purpurea.*

Pedicels slender, 2—6 times as long as the calyx.

Leaves linear, spreading or ascending; capsule globose.

Leaves ½—1½ inches long, ¼—1 line wide. *G. tenuifolia.*

Leaves 1½—3 inches long, 1 2 lines wide. *G. besseyana.*

Leaves subulate, short, nearly erect; capsule oblong. *G. skinneriana.*

** *Flowers sessile; anthers pointless, those of the two shorter stamens smaller. G. auriculata.*

GERARDIA ASPERA *Dougl.*; Benth. in D. C. Prodr. 10:517. 1846. Rough Purple Gerardia.

Gerardia longifolia Benth. Comp. Bot. Mag. 1:208. 1835. Not Nuttall.

Stem somewhat branched, 1—2 feet high, hispidulous-scabrous; leaves narrowly linear, rough-hispid; pedicels equaling or about twice the length of the calyx; calyx-lobes triangular-lanceolate, shorter than the tube; corolla one inch long, purple, glabrous within, pubescent without.

This is a prairie species growing in a dry soil, and ranging from Indiana to Michigan, Minnesota, South Dakota, and Nebraska, south to Missouri, Arkansas, and Texas. The flowers open in August and September.

Within our limits this Gerardia seems to be infrequent. Our specimens are from Emmet and Decatur counties. In the latter locality only a single specimen was found, and this one was growing with *Gerardia auriculata* of which there was a considerable colony. The State University herbarium has specimens from Delaware, Henry, and Lyon counties. Professor Pammel reported the species from Woodbury county; Professor Hitchcock from Story county; and Messrs. Barnes, Reppert, and Miller from Muscatine county.

Arthur, Contr. Fl. Ia, p. 23; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Pammel, Proc. Iowa Acad. Sciences, Vol. 3, p. 127; Shimek, Bull. Lab. Nat. Hist., S. U. I., Vol. 3, p. 207; Iowa Geol. Sur., Vol. 10, p. 173; Halsted, Bull. State Agr. Col., Nov., 1886, p. 52; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 157; Manual Fl. Plants of Iowa, p. 125; Barnes, Reppert, and Miller, Proc. Davenport Acad. Sciences, Vol. 8, p. 244.

GERARDIA PURPUREA *L.* Sp. Pl. 610. 1753. Large Purple Gerardia.

Gerardia maritima var. *major* Chap. Fl. S. St. 300. 1860.

Stem 1—2 feet high, glabrous, branched; leaves narrowly linear, rough-margined; flowers racemose, purple, pedicels usually shorter than the calyx.

This species ranges from Maine to Minnesota, south to *Florida, Mississippi*, and Texas. Britton and Brown state

that the species is mostly near the coast. In Iowa the species occurs in damp soil, blooming in August and September, and is infrequent. Type locality: "Habitat in Virginia, Canada."

On August 19, 1900, we found in Johnson county a considerable colony of this species by the roadside associated with *Gerardia tenuifolia*. The purple flowers were an inch long, the leaves linear, and slightly scabrous. The forms agree very well with specimens collected near Lake Michigan, Indiana, by Agnes Chase. The State University has a specimen from Emmet county collected by Mr. Cratty. Prof. Bessey reported the species from Story and Poweshiek counties; Prof. Fink from Fayette county; Prof. Pammel from Hamilton county; Messrs. Barnes, Reppert, and Miller from Scott and Muscatine counties; and Mr. Miller by note from Henry county.

Arthur, Contr. Fl. Ia., p. 23; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Pammel, Plant World, Vol. 2, p. 44; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Shimek, Bull. Lab. Nat. Hist., S. U. I., Vol. 3, p. 208; Fitzpatrick, Manual Fl. Plants of Iowa, p. 125; Barnes, Reppert, and Miller, Proc. Davenport Acad. Sciences, Vol. 8, p. 244.

GERARDIA TENUIFOLIA *Vahl.* Symb. Bot. 3:79. 1794. Slender Gerardia.

Gerardia purpurea L. Sp. Pl. 610. 1753. In part.
Gerardia erecta? Walt. Fl. Car. 170. 1788.
Anonymous erecta? Walt. Fl. Car. 170. 1788.

Stem about 10 inches high, glabrous, paniculately branched; leaves narrowly linear; pedicels exceeding the vertically compressed corolla, often longer than the leaves, slender; calyx small, with five short acute teeth; corolla light purple, about one-half inch in length; capsule globose, scarcely exceeding the calyx.

This species is common in fields and thickets, usually preferring low dry or rather moist soil, and blooming in August and September. The species ranges from Ontario and New England to Manitoba and Minnesota, south to New Jersey, Florida, Alabama, Louisiana, and Arkansas. The type locality is unknown.

Specimens in our herbarium are from Johnson, Washington, and Decatur counties. We have observed the species in Winneshiek and Jefferson counties. The State University herbarium has specimens from Delaware, Henry, Des Moines, Winnebago, Emmet, and Lyon counties. Prof. Bessey reported the species from Poweshiek and Story counties; Prof. Pammel from Harrison county; Messrs. Nagel and Haupt from Scott county; Prof. Fink from Fayette county; and Messrs. Barnes, Reppert, and Miller from Muscatine county.

Arthur, Contr. Fl. Ia., p. 23; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Pammel, Proc. Iowa Acad. Sciences, Vol. 3, p. 127; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Shimek, Bull. Lab. Nat. His., S. U. I., Vol. 3, p. 208; Iowa Geol. Sur., Vol. 10, p. 177; Halsted, Bull. State Agr. Col., Nov., 1886, p. 52; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124 & p. 157; Manual Fl. Plants of Iowa, p. 126; Barnes, Reppert, and Miller, Proc. Davenport Acad. Sciences, Vol. 8, p. 244.

GERARDIA TENUIFOLIA ASPERULA *A. Gray*, Bot. Gaz. 4:153. 1879.

This variety differs from the typical form in having the leaves linear filiform and scabrous on the upper surface. The corolla is not compressed.

This variety ranges from Ontario and Indiana west to Minnesota, Missouri, Tennessee, Alabama, and Louisiana. In reference to the type locality Professor Gray says: "Collected at St. Croix, Wisconsin, and in Fillmore county, Minnesota; also received from Michigan and St. Louis."

The only specimens we have of this variety is from Johnson county. Messrs. Barnes, Reppert, and Miller report the variety as occurring on a dry hill at Wild Cat Den, Muscatine county.

Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 244.

GERARDIA BESSEYANA *Britton*, Mem. Torr. Club, 5:295. 1894.

Gerardia tenuifolia var. *macrophylla* Benth. Comp. Bot. Mag. 1:209. *1835. Not G. macrophylla* Benth.

Gerardia tenuifolia var. *macrophylla* Benth. of Gray's Manual and Snyoptical Flora.

Stem glabrous, rather stout, 1—3 feet high, strict or with erect or ascending branches; leaves linear, scabrous, acute, ascending, 1—2 inches long, 1—2 lines wide; pedicels longer than the flowers, ascending; calyx campanulate; the calyx-teeth triangular-subulate, about one-third the length of the calyx-tube; corolla purple, 5—6 lines long; capsule globose, exceeding the calyx, 2—3 lines in diameter.

This species grows in dry soil on the rolling prairies of Iowa, Nebraska, Colorado, south to Louisiana and Kansas. Its eastward range is not definitely known. Western Iowa was for a long time considered the eastern limit of the range. We have a specimen collected by Agnes Chase along the Desplaines river, Thatcher's Park, Illinois. This species blooms from July until September.

The State University herbarium has a specimen from Fremont county. Professor Arthur reported the species from Pottawattamie county.

Arthur, Proc. Davenport Acad. Nat. Sciences, Vol. 4, p. 170; Gray's Manual, Ed. 6, p. 390; Synop. Fl., Vol. 2, Pt. 1, p. 294; Britton and Brown, Ills. Fl., Vol. 3, p. 177; Shimek, Bull. Lab. Nat. Hist., S. U. I., Vol. 3, p. 208; Fitzpatrick, Manual Fl. Plants of Iowa, p. 126.

GERARDIA SKINNERIANA *Wood*, Classbook, 408. 1847.

Gerardia parviflora Chap. Fl. S. States, 300. 1860.
Gerardia setacea Gray's Man. Eds. 1—5. Not Walter.

Stem 6—18 inches high, striate, simple or branched; leaves setaceous, one-half to an inch long, one-half line or less wide, the upper minute; pedicels 2—4 times the length of the capsule, about the length of the flowers; calyx-teeth minute; corolla light purple, about one-half inch long; capsule oblong, 2—3 lines high, about twice the length of the calyx.

This species ranges from Massachusetts to Minnesota and Iowa, south to Florida, Alabama, and Louisiana. The species blooms in July, August, and September, and grows in sandy soil in woods and thickets. Concerning the type

locality Prof. Wood says: "I detected this delicate species in July, 1846, in Greene county, Ia."

We have no Iowa specimens of this species. Prof. Wood reported the species from Greene county as above noted and Prof. Arthur includes the species in his catalogue under the name of *Gerardia setacea* Walt.

Wood, Classbook, p. 408; Arthur, Contr. Flora of Iowa, p. 23; Britton and Brown, Ills. Fl., Vol. 3, p. 177; Gray, Synop. Fl., Vol. 2, Pt. 1, p. 294; Mohr, Plant Life of Alabama, p. 727.

GERARDIA AURICULATA *Michx.* Fl. Bor. Am. 2:20. 1803.

Rough-hairy; stem 1—2 feet high, simple or branched above; leaves lanceolate or ovate-lanceolate, acuminate, sessile, entire, many with an oblong or lanceolate lobe on one side at the base; flowers solitary, sessile, purple.

This species ranges from Pennsylvania to Minnesota, south to North Carolina and Kansas, preferring moist prairie soil, and blooming from July until the close of September. Type locality: "HAB. in pratis regionis Illinoensis." In Iowa the species is frequent.

Specimens in our collection are from Johnson and Decatur counties. The State University herbarium has a specimen from Henry county. Prof. Bessey reported the species from Story and Poweshiek counties; Prof. Fink from Fayette county; Messrs. Nagel and Haupt from Scott county; Messrs. Barnes, Reppert, and Miller from Muscatine county, and Prof. Upham from Emmet county.

Arthur, Contr. Fl. Ia., p. 23; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p, 160; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Halsted, Bull. State Agr. Col., Nov., 1886, p. 52; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 157; Manual Fl. Plants of Iowa, p. 126; Upham, Flora of Minn., p. 101; Barnes, Reppert, and Miller, Proc. Davenport Acad. Sciences. Vol. 8, p. 244.

AFZELIA *J. G. Gmel.* Syst. Nat. 2:927. 1796.

[SEYMERIA Pursh, Fl. Am. Sept. 2:736. 1814.]

Erect branching perennials, with opposite dissected or entire leaves, and yellow flowers. Calyx campanulate, 5-cleft, corolla-tube short and broad; limb of 5 ovate or oblong nearly equal spreading lobes. Stamens 4, nearly equal.

AFZELIA MACROPHYLLA (*Nutt.*) *Kuntze*. Mullen Foxglove.

Seymeria macrophylla Nutt. Gen. 2:49. 1818.
Gerardia macrophylla Benth. Comp. Bot. Mag. 1:205. 1835.
Afzelia macrophylla Kuntze, Rev. Gen. Pl. 457. 1891.

Stem 3—6 feet high, pubescent to glabrate; lower leaves pinnatifid, divisions lance-oblong, incised; the upper lanceolate, serrate or entire; flowers short-pedicelled, axillary, in a long interrupted spike; corolla woolly inside; filaments woolly; style short; capsule globose or ovoid, tipped with a flat mucronate point, many-seeded.

This species ranges from Nebraska and Iowa to Ohio, south to Kentucky and Texas. The species grows in moist soil in woods near water courses and blooms during the months of July and August. Within our limits the species may be said to be frequent but somewhat local in its distribution, often there being a colony of many individuals in one locality outside of which none will be found for many miles, one colony to a county being the rule. Type locality: "HAB. in shady alluvial soils on the banks of the Little Miami (Ohio), near the town of Lebanon."

Specimens in our collection are from Johnson, Des Moines, Van Buren, Decatur, and Page counties. We have observed the species in Muscatine county from which locality there is a specimen in the State University herbarium. Messrs. Barnes, Reppert, and Miller report the species from Scott county.

Arthur, Contr. Fl. Ia., p. 23; Gray's Manual, Ed. 6, p. 388; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 157; Vol. 6, p. 192; Manual Fl. Plants of Iowa, p. 126; Britton and Brown, Ills. Fl., Vol. 3, p. 172; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 244.

CASTILLEJA COCCINEA (*L.*) *Spreng.* Scarlet Painted-cup. Indian Paintbrush.

Bartsia coccinea L. Sp. Pl. 602. 1753.
Castilleja coccinea Spreng. Syst. 2:775. 1825.
Euchroma coccinea Nutt. Gen. N. A. 2:55. 1818.

Annual or biennial, hairy; stem 8—16 inches high; radical leaves clustered, obovate or oblong, entire; cauline leaves incisely cut into segments; floral bracts 3—5-cleft, scarlet; calyx 2-cleft; corolla scarcely longer than the calyx, pale yellow.

This species ranges from Maine and Ontario to Manitoba, south to Virginia, Tennessee, Alabama, Kansas, and Texas. Within our limits the species seems to prefer sandy soil in open woods or on the prairie. The scarlet coloring of the floral bracts gives the species a striking appearance. Formerly this species was quite frequent but is now becoming scarce. The type locality is: "Habitat in Virginia, Noveboraco."

Specimens in our herbarium are from Winneshiek, Johnson, and Appanoose counties. The State University herbarium has specimens from Delaware and Cerro Gordo counties. Prof. Bessey reported the species from Fayette, Floyd, Poweshiek, and Des Moines counties. Messrs. Nagel and Haupt from Scott county; and Messrs. Barnes, Reppert, and Miller from Muscatine county.

Parry, Owen's Rep. Geol. Sur. Wis. Ia. and Minn., p. 6:6; Arthur, Contr. Fl. Ia., p. 23; Bull. Iowa Agr. Col., Nov., 1884, p. 165; History of Floyd County, p. 308; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Fitzpatrick, Proc Iowa Acad. Sciences, Vol. 5, p. 124, and p. 157; Manual Fl. Plants of Iowa, p 126; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 244.

CASTILLEJA SESSILIFLORA *Pursh*, Fl. Am. Sept. 2:738. 1814. Downy Painted-cup.

Euchroma grandiflora Nutt. Gen. N. A. 2:55. 1818.
Castilleja grandiflora Spreng. Syst. 2:775. 1825.

Perennial; stem 6—14 inches high, grayish pubescent; leaves oblong-linear, entire or 5-cleft, divisions narrow,

diverging; floral leaves similar; calyx deeply cleft; corolla long.

This species grows in dry soil on prairies from Manitoba, Wisconsin, and Minnesota to the northwest territory, south to Illinois, Iowa, Nebraska, Wyoming, and Texas, blooming during the months of May, June, and July. In Iowa the species is frequent in the western portion but infrequent in the eastern portion. Type locality: "In upper Louisiana."

Specimens in our herbarium are from Shelby and Emmet counties. The State University herbarium has specimens from Delaware, Story, Hardin, Hamilton, and Lyon counties. Professor Pammel has reported the species from Woodbury county.

Arthur, Contr. Fl. Ia., p. 23; Bull. Iowa Agr. Col., Nov., 1884, p. 165; History of Floyd County, p. 308; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Pammel, Proc. Iowa Acad. Sciences, Vol. 3, p. 128; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Shimek, Bull. Lab. Nat. Hist., S. U. I., Vol. 3, p. 208; Iowa Geol. Sur., Vol. 10, p. 173; Fitzpatrick Proc. Iowa Acad. Sciences, Vol. 5, p. 157; Manual Fl. Plants of Iowa, p. 126.

PEDICULARIS *L.* Sp. Pl. 603. 1753.

Perennials; leaves pinnatifid, the floral bract-like. Flowers yellow, spicate. Calyx inflated, 2—5-cleft. Corolla 2-lipped; the upper lip vaulted, covering the 4 didynamous stamens; the lower lip spreading, 3-lobed. Anther-cells equal.

PEDICULARIS CANADENSIS *L.* Mant. 86. 1767. Lousewort. Wood Betony.

Pedicularis gladiata Michx. Fl. Bor. Am. 2:18. 1803.
Pedicularis æquinoctialis HBK. N. Gen. et Sp. 2:332. 1817.

Hairy; stems usually tufted, 6—12 inches high; leaves alternate, petioled, pinnatifid, segments toothed; flowers in a dense spike; calyx incised in front, oblique; upper lip of the corolla hooded, incurved, with two teeth; capsule flattish, sword-beaked.

This species grows in fields and woods, preferring dry soil, and within our limits it usually blooms during May and June. The species has quite an extensive range, being found from Nova Scotia to Manitoba, south to Florida, Alabama, Louisiana, Kansas, Colorado, Texas, and northern Mexico. Linnæus gave the type locality as: "Habitat in America septentrionalis. Kalm."

Specimens in our herbarium are from Winneshiek, Johnson, Decatur, and Shelby counties. We have observed the species in Allamakee and Clayton counties. The State University herbarium has specimens from Story, Dallas, Cerro Gordo, Hancock, Calhoun, Pottawattamie, Emmet, and Lyon counties. Professor Bessey reported the species from Warren, Poweshiek, Floyd, Fayette, and Des Moines counties. Messrs. Nagel and Haupt from Scott county; Messrs. Barnes, Reppert, and Miller from Muscatine county; and Mr. Mills, by note, from Henry county.

Parry, Owen's Geol. Sur. Wis., Ia. and Minn., p. 616; Arthur, Contr. Fl. Ia., p. 23; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Shimek, Bull. Lab. Nat. Hist., S. U. I., Vol. 3, p. 208; Iowa Geol. Sur., Vol. 10, p. 175; Halsted, Bull. State Agr. Col., Nov., 1885, pp. 7, 43, & 48, and Feb., 1888, pp. 43 & 44; Fitzpatrick, Proc. Iowa Acad Sciences, Vol. 5, p. 124 & p. 157; Manual Fl. Plants of Iowa, p. 127; Rigg, Notes on the Flora of Calhoun County, p. 22; Barnes, Reppert, and Miller, Proc. Davenport Acad Nat. Sciences, Vol. 8, p. 244.

PEDICULARIS LANCEOLATA *Michx.* Fl. Bor. Am. 2:18. 1803. Swamp Lousewort.

Pedicularis auriculata Smith in Lees' Cyclop. 1814.
Pedicularis virginica Poir. Enc. Meth. 5:126. 1804.
Pedicularis pallida and *resupinata* Pursh, Fl. N. A. 424. 1814.
Pedicularis auriculata Sm. ex Benth. D. C. Prodr. 10:577. 1846.

Stem 1—2 feet high, somewhat hairy or glabrous; leaves mostly opposite, lance-oblong, pinnately lobed, crenate-toothed, spike dense; calyx 2-lobed; the upper lip of the corolla larger, covering the lower; capsule ovate, about the length of the calyx.

This species ranges from Connecticut to Ontario and Virginia, west to Ohio, Michigan, Minnesota, Manitoba,

Iowa, and Nebraska. In Iowa this species occurs in swampy places, blooming in August and September, and is frequent in occurrence. Type locality: "HAB. in regione Illinoiensi."

Specimens in our collection are from Winneshiek and Johnson counties. The State University herbarium has specimens from Winnebago, Hancock, Emmet, and Lyon counties. Professor Bessey reported the species from Story, Floyd, and Poweshiek counties; Messrs. Nagel and Haupt from Scott county; Professor Fink from Fayette county; and Messrs. Barnes, Reppert, and Miller from Muscatine county.

Arthur, Contr. Fl. Ia., p. 23; Nagel and Haupt, Proc. Davenport Acad. Nat. Sciences, Vol. 1, p. 160; Hitchcock, Trans. St. Louis Acad. Science, Vol. 5, p. 511; MacMillan, Met. Minn. Valley, p. 471; Fink, Proc. Iowa Acad. Sciences, Vol. 4, p. 97; Bessey, Fourth Bien. Rep. Agr. Col., p. 112; Shimek, Bull. Lab. N. Hist., S. U. I., Vol. 3, p. 208; Iowa Geol. Sur., Vol. 10, p. 178; Halsted, Bull. State Agr. Col., Nov., 1886, p. 52; Fitzpatrick, Proc. Iowa Acad. Sciences, Vol. 5, p. 124 and p. 157; Manual Flowering Plants of Iowa, p. 127; Barnes, Reppert, and Miller, Proc. Davenport Acad. Nat. Sciences, Vol. 8, p. 244.

MELAMPYRUM *L.* Sp. Pl. 605. 1753.

Ours a small branching annual herb, with opposite entire petioled lanceolate or linear-lanceolate leaves, and small white or whitish flowers solitary in the upper axils or more or less spicate. Calyx 4-toothed. Corolla irregular, 2-lipped; the upper lip obtuse or emarginate, the lower lip 3-toothed. Stamens 4, didynamous. Capsule flat, oblique, 2—4 seeded.

MELAMPYRUM LINEARE *Lam.* Encycl. 4:22. 1797.
Narrow-leaved Cow-wheat.

Melampyrum americanum Mx. Fl. Bor. Am. 2:16. 1803.

Puberulent; stem 6—18 inches high, obscurely 4-sided; leaves short-petioled, the floral ovate or lanceolate, with a few bristle-pointed teeth near the base; calyx-teeth subulate; corolla thrice the length of the calyx, the lower lip yellow.